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VIEWS OF PROFESSOR YOUNG ON THE CONSTITUTION OF THE SUN.

We have learned that Dr. Vogel of Potsdam is getting out a new and enlarged edition of Engleman's translation of Newcomb's Popular Astronomy, and that he has asked Professor C. A. Young of Princeton University, (author of Young's series of astronomical text-books), to rewrite and bring down to date for it, his views of the constitution of the Sun, given in the original edition twenty-seven years ago. Knowing this, we asked Professor Young if we could not have this revised statement for publication. He kindly acceded to our request, and, herewith, our readers are favored with a full copy of his latest views on the subject before the statement is published in German in the work mentioned above. Those acquainted with Professor Young's views given in the original edition of 1877, will be interested to notice how few important changes and corrections have been made in the rewriting. The numbers (1) (2) etc. refer to paragraphs similarly numbered in the original edition.—EDITORS.

(1). It seems to me practically certain, as a consequence of the low mean density of the Sun and the enormous force of solar gravity, that in the central portions of the body, and in fact, in all but a comparatively thin shell on the outside, the constituent substances must be in the purely gaseous state on account of the exceedingly high temperature, far above the critical points of any known vapors. But whether all the chemical elements are necessarily in a state of "dissociation," as formerly supposed, is perhaps now doubtful in view of the discovery of compounds (certain carbides, for instance) which are freely formed at the highest temperatures of the electric furnace.

Under the enormous pressure the internal gases are considerably denser than water, and probably so viscous that perhaps it may not be impossible for the nucleus to behave to a certain extent like a pitchy semi-solid globe in permitting peculiar conditions to become for a time "localized," so to speak, at special points; as seems to be suggested by the observed tendency of solar spots and other disturbances to recur at the same points on the surface.

(2 and 3). I still think it probable that the photosphere or visible surface of the Sun consists of an envelope of *clouds* formed by the condensation and combination of such of the solar va-

pors as are sufficiently cooled by their radiation into space. This envelope acts like a "Welsbach mantle" in its intense radiating power, and supplies the continuous background of the solar spectrum. The photospheric clouds are of course suspended in the surrounding gases and uncondensed vapors just as clouds float in our own atmosphere.

From the under surface of this cloud shell, if it really exists, there must necessarily be a continual precipitation into the gaseous nucleus below with a corresponding ascent of vapors from beneath—a vertical circulation of great activity and violence, one effect of which must be a constricting pressure upon the nucleus much like that of the liquid skin of a bubble upon the enclosed air. With this difference, however, that the photospheric cloud-shell is not a continuous sheet but "porous," so to speak, and permeated by vents through which the ascending vapors and gases can force their way into the region above.

As to the thickness of the photosphere, I see at present no means of determining it with certainty: it must be some thousands of miles.

I am aware that this cloud-theory of the photosphere is not free from difficulties, and that much can be said for the hypothesis proposed by Schmidt of Stuttgard, according to which the photosphere is merely an optical phenomenon due to refraction in and around a globe entirely gaseous. But it still appears to me to be almost a necessary consequence of the known laws of physics that a gaseous globe, free in space, and composed to a considerable extent of metallic vapors, must inevitably clothe itself with an envelope of cloud.

(4). The "reversing layer" and chromosphere in my view are simply the uncondensed vapors and gases which form the atmosphere in which the clouds of the photosphere are suspended, but also rise far above them. It is not intended however by the word "atmosphere" to indicate that this gaseous envelope overlying the photosphere is like the atmosphere of the Earth in its mechanical conditions. It cannot be in statical equilibrium under the action of the Sun's gravity, nor in thermal equilibrium, but rather resembles a sheet of flame,—"a prairie on fire" to use the graphic description of Professor Langley.

The so called "Reversing layer" is the thin stratum at the base of the flame-sheet, rich in all the vapors from which the photospheric clouds are formed. Here mainly, and in the depths between the clouds, the dark Fraunhofer lines have their origin; and at the beginning and ending of totality in a solar eclipse the

spectrum of this layer appears for a few seconds as the bright-lined "flash spectrum," first observed by the writer in 1870, and since 1896 abundantly confirmed by photographs in recent eclipses.

The chromosphere is the region above the Reversing layer, and is made up of the gases and vapors which are non-condensible under the conditions there prevailing,—mainly Hydrogen, Helium, and that form of Calcium vapor which gives the H and K lines in its spectrum. Very likely there may be also other gases as yet unidentified.

The prominences are merely masses of these chromospheric gases carried high above the general level by blasts and currents ascending through the photosphere and apparently floating in the lower regions of the coronal atmosphere which overlies the chromosphere. Occasionally metallic vapors (Mg., Na., Si., Fe., etc.) are projected to considerable elevations, especially in the regions surrounding (but not *in*) large and active spots; and in such cases the prominences usually show rapid changes of form and size, with distortion and displacements of the lines in their spectra.

Until very recently these spectral phenomena have been explained as due to explosive pressures, and motions in the line of sight almost incredibly violent. The recent work of Julius and others tends however to show that some of these appearances may be optical only, and due to anomalous refractions in dense metallic vapors.

(5). The corona is still to a certain extent problematical. Unquestionably it is in part an envelope composed of an extremely rare, and as yet unidentified, gas (provisionally called "Coronium"), having a spectrum characterized by a fairly conspicuous bright line long supposed to be the reversal of the "1474" line of Kirchcoff's map (λ, 5316), but lately shown to be slightly more refrangible (λ, 5304). There are also several other lines revealed by eclipse photography in the violet and ultra-violet region which are probably due to the same element.

As to the streamers, which seem to shine partly by reflected sunlight and partly by pure incandescence, it appears from their spectrum that they are not gaseous, but composed of minute particles driven off from the Sun by some repulsive force,—possibly electrical, or perhaps by the repulsive force of radiation, so recently verified in our laboratories.

Their arrangement with reference to the solar surface is obviously determined by forces which, in their action if not their

origin, are analogous to those which control the disposition of auroral streamers in our own atmosphere; but the latter appear to be purely gaseous.

(6). As regards the sun-spots, it seems no longer safe to assume that they are always depressions in the photosphere since it appears to be beyond question from observations made at Potsdam and elsewhere that occasionally, near the limb of the Sun, their heat-radiation exceeds that of the neighboring surface. Possibly this may be explained by the assumption that the absorption of the solar atmosphere for the *luminous* radiations of the photospheric clouds is very much greater than for the non-luminous, long-waved rays emitted by the spot; but the more probable inference seems to be that the spots in these exceptional cases lie at a considerable elevation so as to escape much of the atmospheric absorption. The darkening of the spots is almost certainly due to absorption, and, to a certain extent at least, this absorption is *gaseous*, and not merely "foggy;" this is indicated by the remarkable strengthening of the dark lines of vanadium and some other substances, as well as by the resolution of the green portion of the spot-spectrum into a shading, of closely packed, dark lines.

As to the cause of the spots I find none of the theories thus far suggested wholly satisfactory. Their distribution on the solar surface makes it clear that they are in some way closely connected with the peculiar law of the Sun's surface rotation, and this fact accords with the theory of Faye; but the cyclonic features demanded by that theory are certainly not obvious. It appears also that there is often a close connection between the position of a spot on the Sun's surface and conditions existing in the gaseous, but viscous, nucleus underlying the photosphere. This is indicated by the frequently observed tendency of spots to break out repeatedly at, or near, the same points upon the surface.

There is unquestionably often, perhaps usually, a powerful uprush of chromospheric gases around the edge of a spot, but seldom, if ever, through the umbra itself. Whether the spot is caused by matter descending from above, or is a "sink" in the photosphere due to relief of pressure underneath (as I used to believe), or has some other widely different explanation, I have at present no confident opinion.

I am still in doubt as to the cause of the periodicity of the sun-spots and the nature of the unquestionable connection between solar activity and magnetic disturbances on the Earth. On the

whole however I am still inclined to believe that the periodicity originates within the Sun itself: it is certainly not attributable to any planetary influences, though influences from the regions beyond our system are by no means barred.

(7). The investigations of the past twenty-five years appear to have determined the effective temperature of the Sun as not far from 6000° C., but the "solar-constant" itself seems to be much more uncertain.

Langley's value, 3.0 calories (small) per centimetre per minute, is perhaps nearest the truth; but the Smithsonian observations of 1902 and 1903 seem to require a reduction of about 25 per cent., bringing it down to 2.25.

The question of the constancy of the solar radiation, one of the most important in the whole range of Astrophysical science, still remains unsolved, but there is reason to hope that investigations now preparing, or already in progress, will soon throw light upon it. Its difficulty lies of course in its complication with the vexatious caprices of terrestrial meteorology.

As to the maintenance of the Sun's radiation there can be no doubt that the contraction theory of Helmholtz represents a *vera causa*, and is true so far as it goes; but that it is the whole truth now seems at least doubtful in view of the newly discovered behavior of radium and its congeners. This suggests that other powerful sources of energy may coöperate with the mechanical in maintaining the Sun's heat.

(8). The equatorial acceleration of the solar surface appears to me to have found its true explanation in the investigations of Salmon and Wilsing, who consider it to be a slowly dying survival of conditions, no longer existing, but once prevailing while the solar system was in the process of formation. I am aware that recently others, Emden especially, have attempted to deduce it mathematically as a necessary consequence of the constitution of the Sun. But I fail to be convinced because of doubt as to some of the fundamental assumptions.

Such in brief are my present "opinions," some of which however are held not very confidently. Time doubtless will clear up many points at present obscure; and also, for such is the condition of the search for truth, will in all probability confront our successors with new problems still more perplexing.

PRINCETON, N. J., U. S. A., C. A. YOUNG.
February, 1904.

THE DETERMINATION OF SOLAR MOTION.

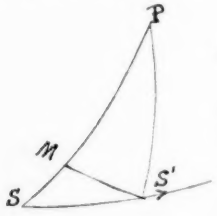
MARY W. WHITNEY.

FOR POPULAR ASTRONOMY.

In October 1897 I presented in POPULAR ASTRONOMY an outline of the problem of solar motion. In that paper no mathematical steps were given. It will be profitable, perhaps, to those readers who are familiar with the elementary principles of analytical geometry and calculus, and understand the bearing of the method of least squares upon the results of observation, if I add at this time the simpler mathematical processes which have been employed by astronomers in their attempts to answer the questions of direction and velocity of solar motion. I will include some of the results of this investigation as obtained by earlier and later astronomers.

The data upon which the investigation rests are the observed changes in right ascension and declination of stars during long periods of time, but usually expressed for working purposes in the changes for one year. Let $\alpha' - \alpha = d\alpha$ and $\delta' - \delta = d\delta$ represent these yearly proper motions in right ascension and declination.

The values for Herschel's graphic process, explained in my first paper, were obtained in the following way.



Let P denote the celestial pole.

SS′ = ρ, the proper motion, considered as taking place along a great circle.

K, the angle PSS′ which the direction of the star's motion makes with the hour circle PS. This is called the position angle of S′.

From S′ draw S′M parallel to the equator. The triangle SS′M may be regarded as a plane right angled triangle. Observation supplies SM and S′M, and we have

$$\begin{aligned} \text{S'M} &= d\alpha \cos\delta = \rho \sin \text{K} \\ \text{SM} &= d\delta = \rho \cos \text{K} \end{aligned} \qquad (1)$$

These equations give K, the position angle by which Herschel plotted the great circles SS′, whose intersections determined his first position of the apex of the Sun's way.

Equations (1) give also ρ, which is the value usually published in text books, for instance the 7″ of Groombridge 1830.

By later and more exact steps of approximation, Herschel arrived at the following values for the right ascension and declina-

tion of the solar apex;

A = 245°.9 D = 40°.4, a point near the star η Herculis.

Herschel also discussed the probable rate of the Sun's motion toward this point. He concluded that the yearly motion of the Sun, viewed at a right angle to its direction, and from the mean distance of first magnitude stars, would subtend an angle of 0″.75.

These first remarkable determinations of Herschel were followed by a method of successive approximation, known generally as Argelander's method. This method assumes values for A and D, and obtains corrections to them, ΔA and ΔD. It may conveniently be considered under three heads, and these three divisions well illustrate the steps frequently taken in an investigation, which passes from a first to a second approximation. The steps may be given in a general way as follows:

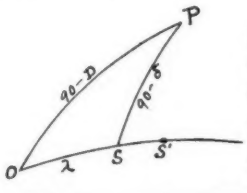
1. Given the approximate values (in our case A and D), find in terms of them some other quantity, which can also be obtained from observed data. Let us call this theoretic or computed value, K_c.

2. Find this K from the observed data. Call it K_0.

3. If the assumed values are correct, the difference $K_c - K_0$ will be zero. If it is not zero, the difference depends upon the errors in our assumed values.

When the differences $K_c - K_0$ (often called, for brevity, C — O) are small enough to be regarded as differentials, we may obtain our corrections to the assumed values by differentiating the equation which expresses the relation between K and these quantities. This is the third step, which we sometimes take even when the differences are too large to be regarded as differentials, because no more exact way is open to us.

In our special case, the quantity selected to be expressed as a function of A and D is the angle (already lettered K) which the star's proper motion makes with the hour circle of the star. For the present, we regard this proper motion as due to solar translation only.



The figure for our first and third steps is the spherical triangle whose vertices are the pole P, the star, S, and the apex of the Sun's way O. SS′ is, as before, the star's proper motion, for the time being regarded as coincident with the great circle OS.

K is the angle PSS′. The angle at P is $\alpha - A$, if α denotes the

right ascension of the star. Let λ denote the angular distance of star from apex, OS.

The application of the well known formulas of spherical trigonometry, given in Chauvenet's Spherical Trigonometry § 114, and often spoken of as the "astronomical group," because of their frequent use in astronomy, gives

$$\begin{aligned} \sin\lambda \sin K &= \cos D \sin(\alpha - A) \\ \sin\lambda \cos K &= \cos D \sin\delta \cos(\alpha - A) - \sin D \cos\delta \end{aligned} \quad (2)$$

Thence

$$\tan K_c = \frac{\cos D \sin(\alpha - A)}{\cos D \sin\delta \cos(\alpha - A) - \sin D \cos\delta} \quad (3)$$

This solution gives also λ, which will be needed in our third step.

The second step, requiring us to obtain κ in terms of observed data, has already been shown in (1), which provides

$$\tan K_0 = \frac{d\alpha \cos\delta}{d\delta}.$$

For every star, we have now its K_c and its K_0.

The difference $K_c - K_0$ depends upon the errors ΔA and ΔD. But it does not depend on these alone. It is caused, secondly, by the fact that the star has a motion of its own, called its peculiar proper motion, which does not carry it along the circle OS. This peculiar proper motion may run in any direction. Thirdly, the difference depends upon the small, unavoidable errors of observation which we call accidental errors. For the time being, however, let us consider only the first of the three.

To obtain, on this supposition, the relation between $K_c - K_0$ and the errors in A and D (all now regarded as differentials), we suppose our spherical triangle subject to variation through the change in the position of O; i. e. $90 - \delta$ is the only constant part of the triangle. Applying the general differential formula for the spherical triangle,

$$\sin a dB = \sin C db - \cos a \sin B dc - \sin b \cos C dA,$$

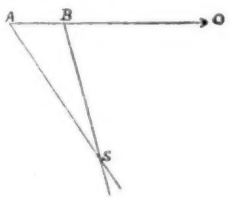
where dc, in our case, is zero, and making substitutions for sin O and cos O, by aid of the "astronomical group" already referred to, we obtain,

$$dK \sin\lambda = \frac{\cos\delta \sin(\alpha - A)}{\sin\lambda} dD - \frac{\cos D \sin\delta - \sin D \cos\delta \cos(\alpha - A)}{\sin\lambda} d\Delta \cos D. \quad (4)$$

Every star involved gives an equation of the form (4). This, then, is the relation between our known values, dK, and our desired values dD and dA, if we ignore the star's own motion and the accidental errors of observation. But what are we to do about these? Here the method of least squares comes to our help. It can deal with the accidental errors by its principle of probability, and at the present time we are forced to let it deal in like way with the stars' own motions. Since we have reason to believe that most of the stars are travelling in all possible independent directions, i. e. are controlled by no common centers of attraction, we may subject them also to the theory of probability, and assume that the method of least squares will eliminate them. In a large degree the results have justified this assumption. If they are not thus eliminated, there will remain some indication of their vitiating effect, as will be later shown.

The solution by least squares of the group of equations (4), one for each star, will give the most probable values of dA and dD, which, applied to the assumed A and D, determine the most probable position of the apex, as based upon the stars involved in the investigation. Argelander applied this method in 1838 to the proper motions of 390 stars. He first selected about 500 stars, which by comparison of Bradley's catalogue (1755) with Piazzi's (1800) showed a sensible proper motion. Of these, he observed himself, about 1830, the 390 used in his discussion. Thus an interval of 75 years was secured for the determination of proper motion. His published results are: A = 259°.8 D = 32°.5. This locates the apex between π and μ Herculis.

Argelander did not consider the rate of solar motion. But a little later (1844) Otto Struve approached the subject in the following way. In the first equation of (2), he substituted $\sin K = \frac{d\alpha \cos \delta}{\rho}$, as given by (1) and $\sin \lambda$, as given by the accompanying figure.



Let d denote distance of star, and l the Sun's linear velocity per year, AB, temporarily assumed, as before, to be the sole cause of proper motion. Under this assumption ASB = ρ. BAS is the λ of (2), the angular distance of star from apex.

Therefore

$$\frac{\sin \lambda}{\rho} = \frac{d}{l}$$

and

$$d\alpha \cos \delta = \frac{l}{d} \cos D \sin (\alpha - A) \qquad (5)$$

A similar equation could be formed for $d\delta$. If d were known, l could be derived. In 1844 little accuracy could be assigned to stellar parallaxes, and Struve did not attempt, as Herschel did not, to find l. With both, $\frac{l}{d}$ was treated as the unknown quantity. Struve assumed certain ratios for the distances of stars of different magnitudes, which his father W. Struve had already published. He obtained, for the mean distance of stars of the first magnitude, $\frac{l}{d} = 0''.34$, a value much smaller than Herschel's.

By regarding the Argelander values of A and D as approximate, i. e. $A = A_0 + dA$ and $D = D_0 + dD$, Struve entered in his equations two other unknown quantities, dA and dD. In fact, he introduced these before he made his final least squares solution, and obtained them at the same time with $\frac{l}{d}$. His investigation was based upon the proper motions of 400 stars.

His values for the apex were,

$$A = 261°.4 \qquad D = 37°.6$$

In 1847 Galloway published another determination of A and D, following Argelander's method, and employing mostly southern stars. He found

$$A = 260°.0 \qquad D = 35°.4$$

In 1856 Mädler renewed the discussion by the Argelander method, making use of 2163 of Bradley's stars, which were reobserved at Dorpat. His values are:

$$A = 261°.6 \qquad D = 39°.9$$

These results, from Herschel to Mädler, present a remarkable agreement, considering the nature of the data involved, and the unknown influence of peculiar proper motion.

The more modern methods will be considered in a subsequent paper.

JESUIT ASTRONOMY.

WILLIAM F. RIGGE, S. J.

FOR POPULAR ASTRONOMY.

PART II. THE RESTORED SOCIETY 1814-1904.

The Society of Jesus, suppressed in 1773, was restored in 1814. The conditions confronting it had changed considerably during

its extinction, and its progress in all directions was beset with new and greater difficulties. Not to mention the necessity of beginning life over again, and passing through the stages of infancy and adolescence unto maturity, the sciences were being modernized and specialized, and books and instruments and courses of study were increasing in number and in technical character. Competition was becoming keen, and means were proportionately smaller. The restored Society was obliged to build its colleges generally at its own expense, as the race of founders and benefactors was practically extinct, so much so, in fact, that whereas tuition had formerly been free in its colleges, special papal dispensation was now necessary to allow fees to be received in them for their support.* Persecutions and confiscations were as frequent as ever, and even today the Society of Jesus is either outlawed or barely tolerated in most of its former most flourishing European provinces. Its scientific, and notably its astronomical activity was therefore, and is yet, very much embarrassed by the lack of means and of sufficient leisure, no less than harassed by positive opposition and persecution. However, the old spirit of the Order is fully alive, and in the short space of practically three quarters of a century the new Society has nobly emulated the deeds of the old.

In presenting to the reader the astronomy of the new Society of Jesus from the time of its restoration in 1814 until the present year 1904, I shall follow the same general plan as in the preceding sketch of the astronomy of the old Society, 1540-1773. The short duration of the restored Society will be sufficient reason, should my list of facts appear meagre. My reason for presenting them is the opportuneness of annexing this second part to the translation of the first, and the natural and very reasonable desire of the reader to know whether the Jesuits of today have kept up their standard of excellence and are as fully abreast of the age as their brethren of yore.

Let me then begin with the

Observatories.

The number of observatories in the new Society of Jesus already rivals that of the old. While some of these are observatories in the technical sense, in which the directors, with one or more assistants, are able to devote much or all of their time to

* Of the 27 Jesuit colleges in the United States, the one at Omaha is the only one which is endowed. The endowment of this is due to the munificence of the Creighton family.

special research, others on the other hand are only college or students' observatories, the directors of which may or may not have the leisure or the inclination to undertake continuous or even occasional work. The equipment of the observatories of the first class I shall describe somewhat fully, but pass rapidly over those of the second.

Rome, Italy.—"The Roman College has always been the home of science. Here Father Scheiner gathered the material for his famous work, Rosa Ursina. Here also at the western end of the present church of St. Ignatius Fr. Gottignes (Brussels 1630-Rome 1689) discovered markings on Jupiter and observed comets. Here Fr. Asclepi (Macerata 1706-Rome 1776) wrote on stellar aberration and the orbits of comets. Here, in what is now called the *Kircher* museum, Fr. Borgondius (Brixen 1679-Rome 1745) was wont to observe the stars, and the sun dial erected by Fathers Maire and Boscovich is still to be seen.

But this place was entirely unsuited to the work done and projected. Benedict XIV intended to build and equip a better observatory, but the storm then gathering about the Society of Jesus put an end to these plans.

After the Suppression Joseph Calandrelli, a secular priest and an excellent mathematician, succeeded in carrying out the greater part of all that had been planned, and he may therefore be rightly called the founder of the Roman College Observatory, for in 1787 he erected the observing tower which is at the east end of the college. But as his means were very limited he was unable to equip it except with the small instruments he had used in the private observatory of his patron Cardinal Zelada. Later on the large zenith sector of Fr. Boscovich came into his hands, and he was the first to observe and establish the latitude of the place with it.

The large partial eclipse of the Sun of February 11, 1804, was a fortunate occurrence for Fr. Calandrelli, because it brought Pius VII into his observatory. The Pope was so much interested in what he saw that he promised personally to defray the expenses of a better equipment.

When Leo XII in 1824 gave back this observatory to the Society of Jesus, Fr. Calandrelli departed with his assistants Conti and Ricchebach, and took the greater part of the instruments along with him to the college of St. Apollinaris, to the disappointment of the Pontiff who had expected that Calandrelli at least would remain. The Pope would perhaps have erected another telescope in the vacated place, but he died three years

later."*

The Jesuits appointed Fr. Dumouchel as director, supplied him with some instruments and gave him Fr. De Vico as an assistant. The management of the observatory devolved more and more upon Fr. De Vico until he became the official director at Fr. Dumouchel's death in 1840. By means of a Gambey theodolite Fr. De Vico determined the position of the observatory more accurately than had been done before. He was an active observer of the planets, Venus and Saturn especially, and of comets. He also began a Durchmusterung of the stars down to the eleventh magnitude. He added an Ertel meridian circle to the 6-inch Cauchoix equatorial, and introduced the custom, which was widely imitated, of firing a cannon to indicate the moment of noon.

In 1848 the revolution drove the Jesuits from Rome. Fr. De Vico fled to France where he was enthusiastically received by Arago. In England he was offered the directorship of the observatory at Madras, but he preferred to go to Georgetown College, Washington, D. C. Being called on business to London, he died there November 15, 1848, at the early age of 43.

Fr. Secchi, who also had found refuge in Georgetown, was recalled in 1849 to take charge of the Roman Observatory. With the means liberally supplied by Pius IX and the Society, he transferred the observatory in 1853 to the place his predecessors had selected, that is, he built it upon the east and south walls of the college and upon the principal pilasters of the church of St. Ignatius. In 1856 he published his first observations upon double stars, and continued to observe them until 1875. In 1860 he began his spectroscopic work. He observed the total eclipse of the Sun of July 18, 1860, in Spain, and along with Mr. De la Rue, who was stationed about 250 miles away, was the first to apply the photographic camera to this purpose. The result proved the prominences to be solar appendages.† Fr. Secchi's other labors will be found elsewhere in this article.

In 1870 the Italian government seized upon Rome, and as usual the property of the Jesuits was confiscated. The government however was forced to reinstate Fr. Secchi in his observatory, owing to the energetic protests of the scientific world. After the Roman college and its observatory were taken away from them, the Jesuits gradually established themselves at the Gregorian University, where Fr. Adolph Müller now possesses a

* Vox Urbis, 1 March 1903, a bimonthly Roman newspaper written in Latin.

† Clerke's History of Astronomy during the Nineteenth Century, second edition, page 211.

10-inch and a 4-inch Merz telescope. The position of this private observatory, Borgo S. Spirito, 12, is very unfavorable. With no assistants, with meager means of subsistence and daily lectures at the university, Fr. Müller has little time for special work. He has however published quite a number of papers in various journals. He is now busily engaged in preparing for the press the second volume (about 600 pages octavo) of his "Elements of Astronomy."

Kalocsa, Hungary.—The Haynald Observatory owes its existence to the munificence of Cardinal Haynald, Archbishop of Kalocsa. The possession of a 4-inch telescope with which His Eminence delighted to look at the heavens, gradually led up to the idea of founding and equipping the present fine observatory. The building was begun in 1878 and the instruments ordered under the direction of Dr. Nik. v. Konkoly, of O'Gyalla. In September of that year Father Carl Braun arrived and became the permanent director.

The observatory proper occupies the second floor of the Gymnasium. The 4-inch Merz equatorial is mounted in a 3 meter (10 foot) cylindrical dome, and a 7-inch Merz equatorial similarly in a 4 meter (13 foot) dome. A meridian room contains a small transit, and a prime vertical room a universal instrument reading to 2 seconds. The latter may also be mounted upon a pier outside which commands an extensive view of the neighborhood.

The observatory is well equipped for solar work, which has been continuously and systematically pursued since 1884. There are several spectroscopes, a small Vogel with two prisms, a Browning direct-vision with two quintuple Amici prisms, and a large one with ten prisms. In the latter instrument any even number of prisms may be used with automatic adjustments. There are also a position and a double-image micrometers, a Zöllner astrophotometer, a Glan and Vogel spectrophometer, a reflecting circle, chronograph, and several clocks. Fr. Braun's resourcefulness has made all these instruments very convenient to use.

In 1885 Fr. Fényi, the present director, took charge of the observatory, and made the solar prominences the object of his special research. Besides three folio volumes of almost daily measurements of the prominences, and two volumes of meteorological observations, he has written more than a hundred technical articles in various scientific journals, especially in the *Memoria della Società dei Spettroscopisti italiani.** His most important paper

* 24 have appeared in this journal, 11 were read before the French Academy, etc.

is probably the one which appeared in the *Astronomische Nachrichten* No. 3355, and in the *Astrophysical Journal*, Vol. IV., pp. 18-37, under the title "A new point of view for regarding solar phenomena and a new explanation of the appearance on the surface of the Sun."—Father Fényi has also added an excellent meteorological department to his observatory. He is a member of the Astronomische Gesellschaft, the Hungarian Literary Society, the Academia Pontificia dei Nuovi Lyncei, the Montevideo Instituto solare, etc.

Fr. Schreiber became assistant at the Haynald Observatory in 1891. Notwithstanding his failing health he engaged in much literary and scientific research. Besides the first part of this present paper on Jesuit astronomy, he wrote on the solar work of Fr. Scheiner, and the lunar map of Frs. Riccioli and Grimaldi, and invented the ceraunograph for detecting and registering flashes of lightning at a great distance.* His principal astronomical occupation was the observation of sun-spots and the determination of time with the transit. He died March 10, 1903. Fathers Esch and O'Connor have lately become assistants to Fr. Fényi.

Whalley, England.—The observatory of Stonyhurst college dates back to the year 1838-39, when a building consisting of an octagonal centerpiece with four abutting porches or transepts, was erected in the middle of the garden. But it was not until 1845 that a 4-inch Jones equatorial was mounted in the dome. Meteorological observations were begun as early as 1844, and magnetic in 1856 by Fr. Weld. In 1867 the astronomical department was removed to a corner of the garden, and an 8-inch equatorial set up. The work under Fr. Perry's management was chiefly directed to the daily study of the solar spots, faculæ and chromosphere. At his death in 1890 Fr. Sidgreaves became director and began work on stellar spectroscopy. Fr. Cortie has also distingtished himself at the observatory. Fathers Sidgreaves and Cortie are, as Fr. Perry was, prominent members of the Royal Astronomical Society and are frequently chosen to fill official positions. Their writings, technical as well as popular, have given quite a name to the observatory.

At present the equipment consists of a 15-inch equatorial refractor with "Father Perry Memorial" glass, a Jones 4-inch and a Clark 5-inch equatorial refractors, a Cassegrain 9½-inch alt-azimuth reflector, a 7-inch Newtonian reflector, two transits,

* Report of the Director of the Philippine Weather Bureau, 1902, Part II., p. 29.

two sidereal clocks, a chronometer, a heliostat, two direct-vision spectroscopes, one by Browning and the other by Hilger, a large Troughton and Simms spectroscope with four compound prisms by Hofmann, an automatic Browning spectroscope with six prisms and a Christie-Hilger half-prism, a photographic grating spectroscope by Hilger, and a 4-inch disk prism mounted on the 4-inch finder of the equatorial.

Washington, District of Columbia, United States of America.—The observatory of Georgetown College is one of the oldest in the United States. Founded in 1842–43 it was almost co-eval with the Naval Observatory at Washington, while the very oldest observatory, that of Williams College, precedes it by only seven years.

The main building is of brick, and consists of a central portion which is surmounted by a dome covering a 12-inch Fauth equatorial, and two wings, the western for a 4.5 inch Ertel transit instrument, and the eastern for a 9-inch Saegmüller photographic transit. The 4-inch Troughton and Simms meridian circle, which had been in the eastern wing for many years, is now dismounted. A frame annex on the east contains a 6-inch photographic zenith telescope, and a small dome houses the old 5-inch equatorial which was originally set up in the central portion of the main building. There are many smaller instruments and attachments, a Fauth chronograph, a Riefler clock in a partial vacuum, and a number of other clocks. The astronomical library on the second floor of the central portion is very complete and up-to-date.

The observatory was built by Fr. Curley, the first director, whose determination of the longitude in conjunction with Sir G. B. Airy, the Astronomer Royal of Greenwich, England, was made by observing a series of transits of the Moon, and was later on shown by the electric telegraph to have been correct within three-tenths of a second.

The revolution of 1848 sent some assistants to Fr. Curley, the ablest being Fr. De Vico, who however remained but a few months, Fr. Sestini and Fr. Secchi. The last taught physics for a year and made original researches in electricity. His treatise on "Researches in Electrical Rheometry" was published in 1852 in the Smithsonian Contributions to Knowledge, and was the first work from his able and untiring pen.

Fr. Sestini began observations on the colors of the stars, a memoir on which he had published while under De Vico at Rome. In 1850 he observed the spots on the Sun for more than a month and sketched the changes in the Sun's surface. These drawings

were lithographed and published by the Naval Observatory. Father Sestini's literary activity was chiefly employed in mathematics, in which he wrote a series of eight text books, and in the translation and editing of works of piety.

In 1852 Fr. Curley published a volume of 215 pages in quarto entitled "Annals of the Observatory of Georgetown College." With this book, investigation and original work ceased at the observatory for a while, the civil war and the construction of the new college preventing the faculty from paying due attention to the observatory and its instruments.

The year before the centennial celebration of the college in 1889, the observatory entered upon a new and brighter phase of existence. From having been for so long a time a students' observatory, it was henceforth devoted to special research. Fr. Hagen was appointed the director and made stellar photometry his chief work. His numerous articles upon that subject and his Atlas Stellarum Variabilium testify sufficiently to his diligence and to his ability. In 1890 Fr. Fargis became his assistant and perfected the photochronograph, with which extended work was carried on in the transit and the zenith telescope. In 1891 Fr. Hedrick was added to the staff.

Valkenberg, Holland.—At the northeast corner of St. Ignatius College, upon walls built especially strong for the purpose, a 9-inch equatorial was erected in 1896 under a revolving dome. This instrument possesses several interesting features. The center-piece of the tube, the cell and the eye end are of aluminum. The driving clock and the pier are of the Lick type. The lens is by Clacey and the mounting by Saegmuller of Washington, D. C. This equatorial was on exhibition at the World's Fair in Chicago. Its lightness and convenience contrast very favorably with older instruments of equal or even smaller aperture, and it was probably the first American telescope imported into Europe. Its short focal length (9½ feet) renders it especially fit for the observation of variable stars, on which subject Fr. Hisgen, the first director, 1897-1902, and Fr. Esch, 1898-1902, have written many articles for the *Astronomische Nachrichten*. The present director is Fr. Baur.

Besides the 9-inch equatorial there are a 5-inch telescope with an altazimuth mounting, a Breithaupt theodolite for time observations, a sidereal clock, a chronometer, a chronograph, etc.

Fr. Kugler, the professor of mathematics, has written several most valuable papers on ancient Assyrian astronomy, the criticisms of which have been very commendatory.

The following observatories have been completed but a short time ago, and one is even now in process of erection.

Manila, Philippine Islands.—The Manila Observatory may be said to have formally begun its meteorological service in 1865, although observations had been made many years previously. In 1881 it was officially approved by the government of Spain, and in 1901 by that of the United States. The meteorological importance and efficiency of the Manila Observatory far overshadows its astronomical. This is due to many causes, prominent among which are the exceptionally favorable situation of Manila in the Eastern typhoon path, and the governmental approbation and support of the meteorological department. On the other hand astronomy has by no means been neglected.

As early as August 18, 1868, three Jesuits from Manila, Fathers Faura, Nouell and Ricart, observed a total solar eclipse in Mantawaloc-Kekee and secured some excellent photographs and details of the prominences.*

From 1880 up to the present time two very valuable services have been rendered to the public. First, the official time has been given to the city of Manila. After the American occupation this service was extended to all the telegraph stations throughout the islands. Second, about a hundred ship chronometers are annually compared and rated at the observatory free of charge.

In 1894 Fr. Algué began to complete the astronomical equipment, which then consisted of several sextants, portable visual and photographic telescopes, theodolites and a meridian circle reading to seconds. A new and special building was erected at an expense of nearly 40,000 dollars. It consists of three portions devoted respectively to the transit, the equatorial and the chronometers. The equatorial is of 19 inches aperture, the objective being by Merz and the mounting by Saegmuller. The attachments to this instrument are a Toepfer spectrograph constructed in Berlin and like the one at Potsdam, and another by Hilger in London, with a grating 3 inches long. The large dome was made in Barcelona, and erected in Manila in 1898. Three other domes are also to be built for other instruments.

The reflecting zenith telescope invented by Fr. Algué in Georgetown, was used by him in Manila for investigating the variation of latitude for fully two years. At the death in 1897 of Fr. Faura, who had been director for a long time, Fr. Algué was taken away from his astronomical labors and made director of

* Spectrum Analysis by Dr H. Schellen, New York, 1872, p. 225, et seq.

the entire observatory. He is rendering indispensable service to the shipping interests of the Far East by his weather predictions. His barocyclonometer is carried on every ship. In 1900 he came to Washington along with Fr. Clos at the invitation of the government in order to supervise the printing of the large work "El Archipielago Filipino," and now he is at St. Louis preparing a Philippine exhibit for the World's Fair.

Fathers Brown and Zwack have lately been made assistants at the Manila Observatory.

THE CREIGHTON UNIVERSITY,
OMAHA, Neb.

CONCERNING THE SPECTRA OF THE NEW STARS.

H. EBERT.*

Among the most peculiar phenomena of all the astrospectral analyses belong undoubtedly the spectra of the new stars. The more details the great spectrographic aids of modern times have made known in these spectra, viz. in those of Nova Aurigæ and of Nova Persei, the less do they seem capable of being united and of being explained by simple hypotheses. The fundamental type of these spectra is the combined double spectrum consisting of bright lines shifting toward red, and appearing at the same time with these, dark lines of the same element shifting toward violet. This type seemed to demand according to Doppler's principle the existence of at least two heavenly bodies, of which the one must move with greater velocity away from us, the other toward us. But why the one should be distinguished only by lines of emission and the other by lines of absorption offered another grave difficulty for explanation. When it became perfectly clear, that the line-shift of different elements, yes even the shift of the lines of the same element, e. g. of hydrogen, when referred to the Doppler principle of movements in the line of vision yielded different velocities which often did not even agree with regard to the signs, then it was seen that an entirely different principle must be sought. And so J. Wilsing undertook an explanation of the typical spectrum of the new stars on the basis of experiments in which the high potential discharges of Leyden jars between metal electrodes took place under water. In this manner one does in fact obtain spectra which have a great likeness to those of the

* Translated by Miss Isabella Watson, Professor of French and German, Carleton College.

new stars. But if the aforementioned investigator refers the effect thus brought to light to increase of pressure, this explanation might be questioned. G. E. Hale, who let the high potential alternating current of a transformer pass between steel bars with flattened ends under water, and who photographed the resulting spectral phenomena by means of a large concave grating, comes to the conclusion, that the pressures in the spark-distances employed by him can not possibly have been so high that one could explain the shifting of the lines actually observed and corresponding to the experiments of Humphreys and Mohler. Rather it appears from his experiments that the aforementioned phenomenon has a very close connection with the absorption phenomena in the cooler envelopes of vapor surrounding the electrodes; the combined spectrum is obtained as a transition type from the bright-line spectrum to the dark-line spectrum by the addition of salt to the water, and thus without any increase of pressure. N. Lockyer also, who repeated the experiments of Wilsing and varied them in many ways can not agree with Wilsing's conception. Finally, H. Konen has exhaustively studied the influence of the most widely differing conditions of discharge on the appearance of spectral lines, and he comes to the conclusion with regard to the spark discharges emitted under water, that increase of pressure and the broadening perhaps connected with this do not suffice for the explanation of the observations.

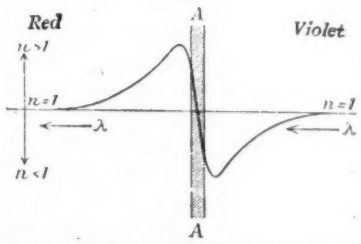
My own experiments in this line led me to the same results. In the bottom of the zinc tub in which the electrodes were held in place from above by movable supports, I fastened under the spark-gap a mirror at an angle of 45°, and opposite this in the tin side of the receptacle I arranged an opening closed by a disk of looking-glass; so the spark-gap was always seen from below; a telescope objective threw the light on first the horizontally and then the vertically placed slit of the different spectrum apparatus used in the experiment. On the under side of the tin tub a pipe was soldered, which, by means of a rubber tube, established communication with the vessel containing the filling fluid (generally water). By raising and lowering the same it was possible to regulate with great exactness the level of the liquid in the discharging vessel and to study the phenomenon while the path of the spark was sunk more or less deeply in the liquid, or just touched the surface of the liquid, or finally was entirely outside of it. The discharges were made by a large Topler induction machine with twenty rotating and forty stationary plates, by means of the parallel action of two very large Leyden jars; in

front of the spark-gap was arranged a spark micrometer, through which the discharge distance was constantly regulated at the same height. The result of many experiments with this arrangement was that the effects of pressure are not sufficient to explain the phenomena.

Another principle of explanation might, as I believe, account in an unforced way for the abnormally great line-shift appearing in the experiments just spoken of, as well as for the appearance of the characteristic double spectra. This principle depends upon the observing of the anomalous dispersion which selective absorbing media exert on the path of rays of light. W. H. Julius has already introduced this phenomenon in several works on the explanations of certain phenomena of solar physics, particularly that of the protuberances; I should like to show that anomalous refractions in absorbing vapor-envelopes under certain circumstances can also very effectually influence the distribution of brightness in the spectrum in the vicinity of the maximum absorption band; this is however just the matter in question with regard to the appearances referred to, especially with regard to those which are typical for the new stars.

Christiansen and Kundt, the discoverers of the anomalous dispersion, had already found, that a medium which possesses for a certain range of wave-length, A (fig. 1), a pronounced absorption band, possesses then when it appears as a refracting medium, for all greater wave-lengths a refracting power increasing abnormally with the approach to the absorption maximum; for the shorter wave-lengths the refracting power is so much decreased that it diverts the wave-lengths situated toward the violet much less than those situated toward the red.

Fig. 1



The metal vapors have strongly marked absorption bands corresponding to their sharp lines of emission; from them, of course, very powerful anomalous dispersion might be expected, even though it is not always easily detected. It is to be attributed only to the experimental difficulties that the number of metal vapors in connection with which the phenomenon in question was known could remain for a long time so small. I pointed out a little while ago that anomalous dispersion is not only very generally diffused in the metal vapors, but also that it extends its

influence in them to a very large range of wave-length, and indeed much farther than could be reached from the influences of movement in the line of sight or from effects of pressure.

R. W. Wood has illustrated by photogram in the case of sodium vapor the influence of such vapor-refractions on extended spectrum fields and I myself have done the same in the case of potassium vapor.

First of all, it is true, only a very few direct measurements of the refracting power are at hand. Such measurements have been made for sodium by H. Becquerel and R. W. Wood, and for potassium by me. Becquerel finds the refraction index for rays which lie toward the red from D_1, $n = 1.0009$; for rays which are toward the violet from D_2, $n = 0.99865$, both indices being referred to the flame-gases surrounding the sodium vapor. The exponent of the same in relation to a vacuum Becquerel reckons at 1.0001, so that the refraction quotients reduced to a vacuum become respectively 1.0010 and 0.99875. R. W. Wood could generate in an atmosphere of hydrogen much denser vapor-masses for which he obtained refractive indices up to 1.0024 and 0.9969 respectively, relative to hot hydrogen. Putting the index of refraction of the latter also at 1.0001, which certainly is nearly right, we have resulting the indices 1.0025 and 0.9970, respectively, when referred to a vacuum. With the 90-degree potassium vapor prisms which I used, I could get from my photogram for the K_α-line, $n = 1.00166$ and 0.99834 respectively; and that with only moderate thickness of vapor, through which still enough light passed so that distinct effects on the somewhat slowly acting plate sensitive to infra-red rays were obtained in a short time. The surrounding of the vapor consisted here also of heated hydrogen, so that the result is $n = 1.00176$ and 0.99844 referred to inter-stellar space.

It is to be noted that in all cases for the rays on the violet side of the region of absorption, for the "higher vibrations," as we will briefly say in analogy with acoustics, refractive indices are obtained which are less than one (1). Here also comes in the curious case that the vapor itself as compared with the vacuum appears as the optically thinner medium; a glance at the course of the dispersion curve shows further that the relative refracting power of the vacuum as compared to the medium increases with the approach to the territory of absorption. On the other hand the experiments teach that this right branch of the curve gets deeper and deeper as the vapor becomes specifically denser. The mechanically denser vapor-envelopes become therefore optically

less and less dense. There is no contradiction in this, though Kundt himself found with solid metals refraction exponents smaller than one (1); according to the electro-magnetic theory of light this apparent anomaly is connected with the abnormal dielectric properties of the metals, in isolated cases probably with the peculiar magnetic properties also.

When one considers that the refraction exponent of the air under atmospheric pressure with relation to the vacuum is just 1.0003, then one recognizes that the refracting power of metallic vapors is a very high one; in the cases mentioned it amounted in the sodium vapor to 8 fold, in potassium vapor to 6 fold that of the air. Consequently more extended layers of such metal vapors, as we may suppose them in the cosmic light sources, must cause very important deviations of the rays. At the same time it is to be remembered, that according to all theories of anomalous dispersion we must regard these deviations as connected with sufficiently strong absorption; it is further to be noted that it only affects the regions of the spectrum neighboring on an absorption line; in these if the refractive index deviates notably from unity to the one side and then to the other, yet the vapor hardly influences the rays of the other wave-lengths perceptibly, since for these the refraction exponent immediately becomes exactly one (1) again and the refracting power becomes null.

In order to recognize how the anomalous dispersion in metallic-vapor masses can affect the distribution of brightness in the spectrum we will now look at the case as illustrated in figure 2.

A metallic-vapor *prism* PP, such as one can manufacture for sodium, potassium or metallic lithium of considerable density by means of the blast-burner suggested by Winkelmann, *stands* with one surface close before the carbons of an arc-lamp B; the whole is surrounded by screens suited to the height, and by means of a lens the light is allowed to fall on the slit placed at a greater distance from the prism edge K. In the figure is drawn on the left the course of the rays for the deeper vibrations bordering on the absorption region of the vapor; on the right those for the higher vibrations under the supposition of a homogeneous density in the interior of the prismatic mass of vapor. Through the first named rays the light of the carbon arc is turned from both sides toward the spectrum apparatus (fig. 2*a*); and this receiyes thus more light in the corresponding spectral region than in the parts of the spectrum which go without refraction through the vapor; the brightness increases about in proportion as the sur-

face of B increases, which by means of the bending of the rays in the prism can send more light to the spectrum apparatus. In the direction of the red in the spectrum, there appears thus an important brightening of the continuous spectrum constantly increasing toward the line of absorption. The rays that are sent out from the white glowing carbons B and that have a greater number of vibrations than those peculiar to the vapor molecules, undergo on the other hand such refraction (fig. 2, *b*) that they do not reach the observer at all or at least only in very diminished number; hence one part in the spectrum is here entirely lacking, or the brightness of the same is very much reduced in comparison with the other parts of the spectrum. The apparent shadow lying in such a manner over the spectrum exceeds by far the actual absorption-space A, as a glance at fig. 1 at once shows. In this form is the phenomenon in question most easily proved by experiment and brought to demonstration.

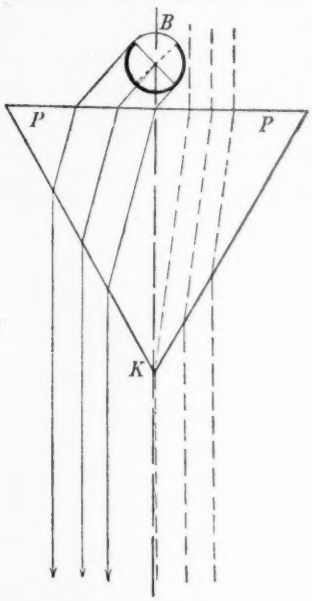


Fig. 2a. Fig. 2b.

Even for this simple example astrophysical applications are conceivable. If B should be a single cloud of the photospheric network, and PP, on the other hand, a thicker absorbing vapor mass lodged over it by wave, or whirling movements in the photosphere of the Sun, and if the point K of the Sun's disk is thrown by the telescope objective on the slit of the spectrograph, then there may appear in the spectrograms, toward the red side of the same, transitory brightenings of the dark absorption lines corresponding to the vapor. Thereby are at once explained abnormities in the solar spectrum such e. g. as were found recently on the plates of the Yerkes Observatory.*

* G. E. Hale, *Astrophys. Jour.* 16 p. 220-233, 1902: compare especially p. 222 and 223 above. On the edges of the dark lines λ 3884.64 and λ 3896.21 there appeared on the side toward the red, bright lines, through which attention was turned to the anomaly before us. The explanation which W. H. Julius gives of the same (in the same place 18, p. 50-64, 1903) is in principle entirely analogous to the one appearing here.

If two luminous masses B (fig. 2) were present, lying behind the points PP, then the reverse must happen; the dark absorption lines must brighten on the edges toward the violet; between these lies the case of symmetrical broadening with central reversal.

The same holds good for the above mentioned example of the condenser-discharges taking place under water. If one causes sparks or alternating current discharges to take place between metal electrodes under a liquid, he obtains cooler and proportionally strong absorbing envelopes of metallic vapor. Immediately against the electrode surfaces themselves the metallic vapors are densest at every separate discharge; then follow layers which con-

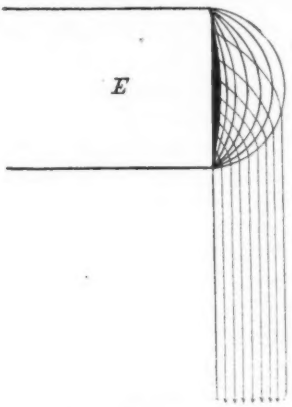


Fig 3a.

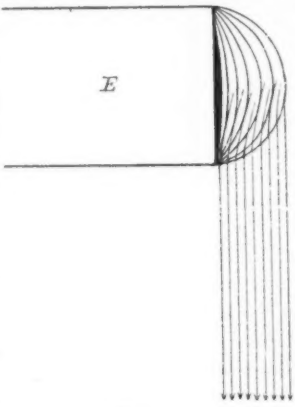


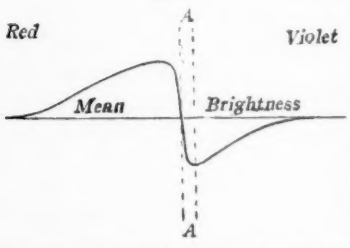
Fig 3b.

tain less and less vaporized metal in the unit of volume. By the figures 3*a* and 3*b* this distribution may be represented in a perfectly schematic way in the case of electrodes EE flattened at the front; in these figures the lines bending farther and farther out to the right are to indicate the separate layers becoming less and less full of vapor.

The researches of Hartmann and Eberhard have very recently shown how quickly, indeed, the intensity of a metallic line decreases with the density of the vapor. Hence, if we look at such a spark-gap from the side we may expect such a ray path as would result if we were to introduce opposite the point of observation, which may be below, rays from outside into the vapor envelopes and were to trace their refraction through them; this is the case for each electrode E; in fig. 3*a* for the deeper vibrations with relation to a metal line with $n > 1$, in fig. 3*b* for the higher

vibrations for which $n < 1$. According to the principle of the reversibility of the path of light, the path of those rays which go out from the points struck in the first case into the spectral apparatus must be reversed. One sees then, that the rays for which the inner layers become more and more refrangible (fig. 3*a*) bring light from the hotter deeper layers, in fact from the inner electrode surfaces themselves into the apparatus; the rays (fig. 3*b*) for which the refraction index of the vapor layers is smaller than that of the surrounding envelope of gas (in sparks under water consisting of course mainly of hydrogen) *yield* on the other hand only light which comes from the cooler outer layers. Fig. 3, it is true, presents only one special case which perhaps seems but little probable. But one can easily draw other distributions and apply to them the preceding observations. For instance, if two flattened electrodes are standing opposite each other at a very small distance in comparison to their thickness, as was the case in the experiments of Hale just referred to, then the metallic vapors will spring out from the narrow opening at each discharge, and all the more, the more the condenser-action in the secondary circuit advances and the action of the self-induction recedes. If one extends the rays brought in from the side, analogous to the above, clear into the protruding layers of vapor surrounding the place of the spark, then one recognizes again that the rays with $n > 1$ point right into the heated path of the spark while those with $n < 1$ prevailingly point toward the outer electrode surfaces which are much cooled by the liquid. If spark-discharges are passed into gases at high pressure the diffusion of the metallic vapors is limited; denser refracting layers gather in the neighborhood of the path of discharge; hence phenomena similar to those with the spark under water may be expected here with sufficient increase of pressure in the surrounding gaseous atmosphere, provided always, that the absorption is sufficient, to which point attention has already been called. Hale's wonderful engravings prove this most completely. In all the cases named the distribution of brightness represented in fig. 4 must result in the neighborhood of the absorption line AA.

Fig. 4



With increasing absorption, indeed, the dark line AA can encroach more and more upon the domain of the brighter ones, so

that its middle seems to be shifted at first only a little and then not at all toward the violet, and eventually even slightly toward the red. With highly increased absorption, the bright lines corresponding to the rays in the vapor envelopes may even under some circumstances disappear altogether in the general background of light.

The great number of individual possibilities admitted by the principle of explanation here offered seems to me to be an essential advantage of the same rather than a disadvantage; yet the number of separate cases appearing with the different metals at the discharge under water or in high gas pressure is likewise enormous.

In its application to the phenomena of new stars the view here described gains an increased probability because it presents the direct completion and a necessary consequence of that theory concerning the phenomenon mentioned, which since then has proved itself most tenable in all other points, namely the Seeliger theory of the new stars.

H. von Seeliger assumes that with the flashing up of a new star a compact celestial body, in itself dark or only slightly glowing, travels with cosmic velocity into an extended cloud of dust which in itself glows but little or not at all. Almost daily celestial photography is teaching us that areas of cosmic dust or vapor are much more frequent in celestial space than was formerly suspected. On the other hand Nova Persei especially has demonstrated in the most evident way the close relation of the new stars to such nebulous formations. With the great relative speed between celestial bodies and particles of dust running against each other, the body must become greatly heated on the surface of its front side; but also the parts of the dust-cloud met and condensed by it must undergo a great increase of temperature, as Seeliger elsewhere has calculated for a few cases under perfectly plausible suppositions. With this heating there must be corresponding vaporization. Those substances will vaporize most quickly and most fully which have the lowest temperature of condensation, that is, helium and hydrogen. A thick covering of these must first accompany the body; metallic vapors are added later in rich measure. After this the phenomenon presents on a large scale in the realm of the fixed star system that which we observe on a small scale at the apparition of a meteor in the upper layers of our Earth's atmosphere. Here, too, then should be found spectral phenomena similar to those in the new stars, since the causes of the same—according to our theory the refraction of

light in the vaporous envelopes—are indeed different in degree but not in kind. Of course they are here incomparably harder to observer, and hence, so far as I know at least, have not yet been observed; the reason lies in the great swiftness of the apparition; while the new stars often show as bright shining objects in the heavens for a whole year's time, the duration of the brightest bolide or fire-ball is limited to seconds. Therefore, so long as chance does not bring a meteor of sufficient brilliancy over the plate of an astrospectrographic photograph, we must wait for the proof of this theory.

Let us trace the course of development of a Nova somewhat more closely: First, at the entrance of the body into the cosmic dust-cloud, a rather sudden light in the sky will inform us that this collision has taken place; this is, as Seeliger has already emphasized, vastly more probable than the collision of two celestial bodies against each other, or the collision of one such body with the members of another solar system. There would follow substantially at first only a continuous spectrum with the region of rays extending itself constantly farther into the ultra-violet.

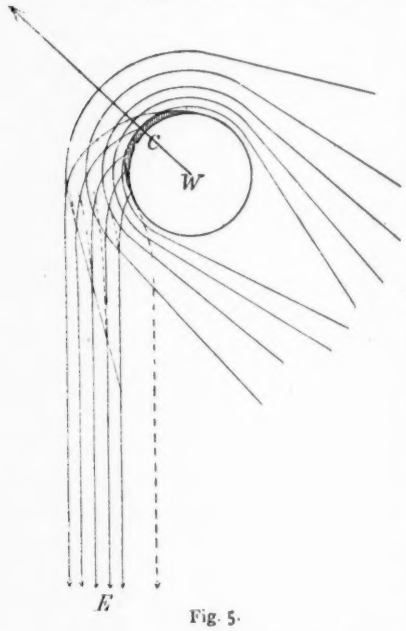


Fig. 5.

But very soon aërifications of the tiny particles must take place in the dust cloud; an absorbing vapor-covering extending itself more and more now surrounds the body, first, as shown above, of H_ϵ and H_2, then of metals. We must imagine the arrangement of the same like that of the condensing waves about a round projectile flying with great velocity through the air, as they have frequently been illustrated by photographic instantaneous exposures by flashlight. In fig. 5 if W represents the body moving through the nebula in the direction of the arrow, then the maximum development of light will take place on the cap C, on the front side in the direc-

tion of the motion. Except in the very improbable case that the body is coming directly toward us, we shall see this brightest part C always more or less obliquely through the envelope of condensed gases and vapors. If then the Earth should chance to be in the direction E, the lines drawn in the figure will indicate the course of light which the spectral colors of the separate absorption lines of a certain element, for instance, that of hydrogen in the red, take. Even in case the observer is standing behind the star in the direction of any one of the stratum surfaces indicated in the figure there will still result a similar course of the rays. For a ray which we imagine to run from him to the star and to enter into the tangential surface separating two strata will be bent toward the direction of the increasing exponent of refraction, in this case inward. Inversely the rays emitted from the heated upper surface parts will reach the observer's eye by a corresponding deflection.

Quite different is the case for the higher vibrations, for which according to p. *242* the outer strata are optically the densest, while those situated nearer the centre have ever decreasing exponents of refraction. Rays of this kind which come from E must take about the course indicated by the dotted lines in the vaporous envelope; for them then the compact body W itself hides the greater part of the illumination developing on the front surface C. Even in case E lies much nearer in the direction of the motion of W than is supposed in the figure, the rays for which $n > 1$ will bring more light to the observer than the rays with $n < 1$. Therefore the absorption lines of those elements of which the envelope is mainly composed must seem in the spectrum to be very much spread out toward the violet (compare fig. 4); a dark shadow apparently stretches itself here over the continuous spectrum serving as a background for the whole; the middle of the line is shifted very strongly toward the violet. But toward the red there seems to be against the bright background a still brighter band whose intensity diminishes gradually toward the red and rapidly toward the violet, that is, toward the absorption line; the brightest edge of this band lies very near the normal place of the line with only a slight deviation toward the red. The brightness of this line may increase almost as rapidly as the dispersion curve itself, fig. 1. Another case may occur for these rays with an $n > 1$ in the strata of the vaporous envelope; this case is especially to be kept in mind and it is this; that the rays with highest n-value do not emerge at all but are entirely reflected. According to Seeliger this

happens with spherical celestial bodies when the height h of the atmosphere is

$$h > (n-1)\,a\cdot$$

(a = radius) for the case when the atmospheric envelope of the variable refraction exponent n borders on a vacuum. Here then the brightness increases only to a certain maximum amount, which remains about the same for a large extent of wave-lengths; there appears a broad bright band of nearly equal intensity which borders sharply on the violet but gradually loses itself toward the red in the common brightness of the continuous spectrum. The centers of these bands are then shifted decidedly toward the red.

For all these cases sketched above, there are found, in the literature concerning the different Novæ, numerous examples which it would take too long to verify singly here.

Beside these diffuse, faded and greatly shifted bright and dark lines which we think of as arising in this way, there may also appear actual emission and absorption lines, sharply defined and narrow, which proceed partly from the gaseous envelope, partly from the celestial body itself. The velocities of movement derived according to the Doppler principle from these narrow and from the broad lines can never give identical values in general; for this too, numerous examples can be found in literature. An essential advantage of the Seeliger theory lies, aside from its great simplicity and naturalness, in the enormous wealth of individual possibilities which it admits. If the celestial body is coming toward us so that we have before it a comparatively thin layer of vapor, then the continuous spectrum and separate bright lines may dominate completely, the doubling of lines is only suggested. If it is moving away from us then we see it through layers of vapor constantly growing thicker, so that the line-shifting may increase to an extraordinary amount. Then a very sudden change may come in when masses of vapor escape and remain behind; there may even occur periodic brightenings such as we observe in our atmosphere at the appearances of meteors; simultaneous with these brightenings may be corresponding periodic changes in the spectrum.

But also through the different densities of cosmic dust-clouds, and variations of density in the same cloud, along the course in which the body passes it, and through the relative velocity of that body, arise new possibilities of individual phenomena. The points of relative maximum density of such a cloud will generally be found on a surface of doubled curvature, so that the body

may traverse several regions of increased density one after the other. Several of the spectral-phenomena are then successively awaiting us. In this way are easily explained the secondary maxima and minima of intensity which are occasionally superposed upon the broadened bright and dark lines in the spectra of the new stars; they are also obtained at the discharge of sparks in water, when one superposes the impression of separate sparks of different strength one upon another on a photographic plate. One needs only to draw the figure 4 once, twice or several times on different scales and to lay them one above another, at the same time simply adding the separate ordinates corresponding to the separate wave-lengths, in order to obtain all the different distributions of brightness with one, two or more relatively darker parts within the bright lines, and inversely bright lines in the dark parts; just as the spectrographs have many times revealed for Nova Aurigæ and Nova Persei. If the celestial body has left the dust-cloud, its brilliancy may decrease with great rapidity, comparatively speaking, if it be essentially only its surface which was heated by the collision with the dust particles, as here supposed; a phenomenon which is also very characteristic of the new stars.

Attention should still be called to one thing which supports this view from an entirely different side; the close connection of the new stars with nebulous patches, as has been discovered, for instance, in Nova Persei, and the corresponding strong relationship of the spectra of new stars with those of different nebulæ.

In a series of variable stars of short period, in whose spectra periodical shifts of the lines occur, the theory here set forth may find application. If the emission of light of a celestial body is essentially different on different parts of its surface, and if it is surrounded with a thick vapor atmosphere, then in its rotation it must offer to the distant observer a phenomenon changing in its development, of the kind described with its shifting and doubling of lines; the period of the same will then be that of its revolution on its axis. So we do not in this case require unconditionally the supposition of two celestial bodies one of which is moving toward us the other away from us.

In the mean time it must not be denied that in all the cases mentioned a role is actually played by shiftings of the lines which result partly from movements in the line of sight according to the Doppler principle, and partly from increase of pressure according to the well-known laboratory experiments in that matter. Through what has been said we wish to show chiefly that

besides motion and pressure the anomalous refractions are to be brought into consideration in the explanation of spectral phenomena of celestial objects.

MUNICH, September, 1903.

SPECTROSCOPE FOR SMALL TELESCOPE.

DAVID E. HADDEN.

FOR POPULAR ASTRONOMY.

During the past eight or ten years the writer has received numerous inquiries from amateur astronomical friends and correspondents for a suitable spectroscope, reasonable in price which could be used for viewing the solar prominences with a small telescope. These inquiries were prompted by the publication, a number of years ago, of a few articles descriptive of a home-made instrument which the writer used in his daily solar observations.

Since that time several desirable changes were made in the design, and a new one constructed which has been used with excellent results up to the present time.

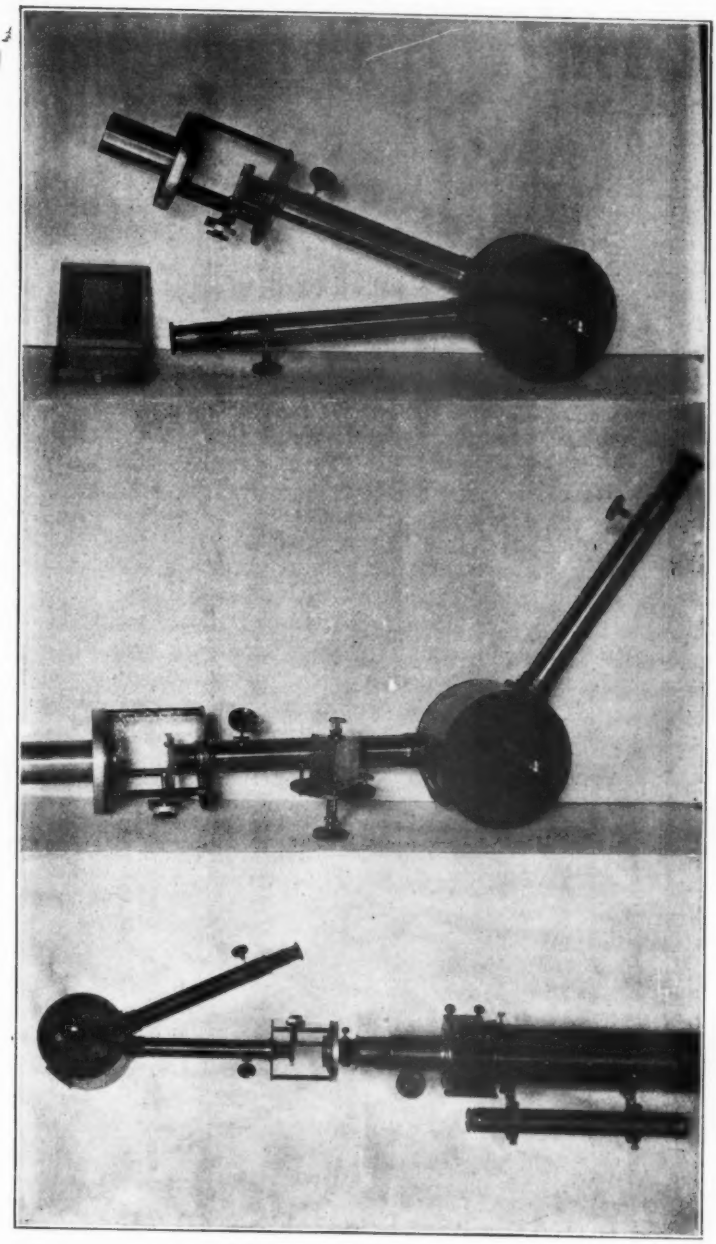
Quite recently, however, a desire to devote more attention to the spectroscopic investigation of the sunspots during the approaching maximum of solar activity, led me to procure a better instrument for this purpose.

Possessing an excellent 2-inch Rowland diffraction grating, which was obtained from Mr. Brashear a number of years ago, I designed the new instrument to accommodate it, and also a dense flint 60° prism.

The instrument was made by Wm. Gaertner and Co., of Chicago, and I am so well pleased with its workmanship, reasonable price and performance, that a description of it may be interesting to the readers of POPULAR ASTRONOMY.

Figure 1 shows the appearance of the instrument used as a grating spectroscope, the observing telescope and collimator each have lenses of one inch diameter and seven and one-half inches focus, with rack and pinion adjustment for eyepiece and slit plate; the latter has German silver sliding plates, with a small micrometer head for measuring the width of slit and determining the height of prominences; the eyepiece tube is supplied with crossed hairs and ½ inch and ⅞ inch eyepieces.

At the end of the collimator tube is firmly fastened a round disc of brass 3 inches in diameter, connected with a similar disc by



three round brass bars 3 inches long and ¼ inch diameter; closely connected with the latter disc is a silvered position angle circle, reading to single degrees; this disc is firmly secured to a short piece of tubing 1¼ inches diameter which can be inserted in the eyepiece tube of the 4-inch telescope or 8½-inch reflector, retained by means of a small clamp, and the entire instrument is securely fastened and all danger of slipping off is prevented. The spectroscope can now be rotated easily at the junction of the disc and position circle and the angle of position of a prominence determined.

The grating table is rotated by hand, but the writer has inserted a couple of geared wheels and by means of a thumb screw nut near the circumference of the grating box, the grating can be easily and smoothly rotated without removing the cover of the box.

Figure 2 indicates the appearance of the instrument when used as a prismatic spectroscope for chemical or stellar work. For this purpose the grating is removed and the small table containing the prism, inserted in its stead, the observing telescope is unscrewed, and screwed into an opening at the proper angle on the side of the grating box, and the openings in either case closed by means of a small cap to exclude all extraneous light.

Figure 3 gives a view of the spectroscope attached to the 4-inch Brashear refractor, and adjusted for viewing the solar prominences or examining spot spectra with the grating. The instrument is brass, light in weight, yet strongly made, and is finished in dull black with tubes polished and lacquered.

ALTA, Iowa.
Feb. 15th, 1904.

ANNA WINLOCK.

MARY E. BYRD.

FOR POPULAR ASTRONOMY.

Anna Winlock was born in Cambridge, Massachusetts, September 15, 1857. The eldest child of Joseph and Isabella Lane Winlock, she had the happy birthright of distinguished ancestry. On the side of both father and mother her lineage is traced back to old Virginia families that helped to win American independence, and later to found the new states of Kentucky and Missouri.

Her father, though his life was short, connected the family name indelibly with astronomy, and Anna Winlock as a child had her home in Harvard College Observatory. It was also under astronomical auspices, at the time of the total solar eclipse of 1869, that her first visit was made to the old home in Kentucky.

She was educated in the Cambridge schools, showing quite early a taste for mathematics, and in the high school excelling in Greek. It was not a common thing in those days for young girls to study Greek and at the time of graduation she received a letter from the principal expressing in the warmest terms his appreciation of her Greek and of her character. Two months later, a young girl in her teens, with no training beyond that of the high school, she took up, in a humble way, her father's work, cut short by his sudden death in June, 1875.

The largest and finest instrument which he had added to the equipment, while director of Harvard College Observatory, was the meridian circle, made by Troughton and Simms, of London, from specifications which included a number of improvements suggested by himself. This instrument was mounted and ready for use in the latter part of 1870, and its possession made it possible for the observatory at Cambridge to join with a number of foreign observatories in a comprehensive scheme for preparing a great star catalogue which should give accurate places of most of the stars in the northern heavens from the first to the ninth magnitudes inclusive. The portion of the sky to be observed for the catalogue was divided into fourteen sections or zones by circles parallel to the celestial equator. A beginning was made promptly on the Cambridge zone, which extended from the 50th to the 55th parallel of north declination. Observations and reductions were placed under the immediate charge of the astronomer, William A. Rogers; and the director, Mr. Winlock, lived to see five years of the work accomplished.

It was in connection with these meridian circle observations that Miss Winlock's first computing was done at Harvard College Observatory. With the first entry of her name in the record books, appear the brief headings, "Copying observations," "Taking means." She began work on the Cambridge zone as a school girl, before it was finished, she was furthering its progress as an astronomer.

Perhaps it is fortunate that in the early years she could not realize how long and arduous was the undertaking to which she had set her hand. The Cambridge zone was among the first to

be published, but it bears the date of 1891, and it was not until five years later that the last supplementing volume appeared. In the catalogue proper there are 8627 stars, and of these more than 26,000 observations were taken, each one including transits for right ascension and declination as well as the reading of microscopes.

The mere routine part of the computing is appalling. To read the chronograph record for one evening required about the same time as to take the observations themselves, and then the reduction was hardly begun. On one page of one of the seven volumes of the Annals of Harvard College Observatory, devoted to this zone, there are more than three thousand figures, in the volume, more than 290 pages of figures so that the whole number counts up to hundreds of thousands. All in all the published figures must be reckoned in millions and for each figure in print there are doubtless ten or twenty back of it upon which it depends for its value, each and every one of which demanded care and thought. And after all else was done there remained the laborious task of checking: for star places must be about as trustworthy as logarithms.

Accuracy in simple calculations lies at the foundation of success in reducing astronomical observations but a far higher type of ability is required to comprehend observations and reductions as a whole, to understand the connection between note-book records and chronograph sheets and the pertinent precepts of theoretical astronomy, and to adapt and apply mathematical formulæ to attain the ends sought. This ability Miss Winlock evinced early, and it was joined to a power for conscientious, persistent work still more rare. During the many years in which the Cambridge zone was in process of preparation, Mr. Rogers had help from five or six assistants. Their periods of labor were some shorter, some longer; but one by one they dropped off. Even he himself had severed his official connection with Harvard College Observatory, before the printing was completed. But Miss Winlock worked on and on, for more than twenty years, developing no small power as a mathematical astronomer, and taking an ever increasing share of responsibility till in the end Mr. Rogers regarded her not so much an assistant as a co-worker. Well had she earned that recognition; and the work of her patient years is builded for all time into the catalogue of the Astronomischen Gesellschaft, of which the Cambridge zone is an integral part. All the zones combined give a catalogue of more than a hundred thousand stars, containing fundamental data for a large part of

the work of precision in astronomy, honored by constant use in large and small observatories by a great body of investigators.

While Miss Winlock's devotion to this catalogue was almost co-extensive with her life, what she thus accomplished was by no means her only contribution to astronomy. Before the last volume of the journal of the zone was published, she was aiding in other researches of the observatory. Under her supervision a table was prepared for volume XXXVIII of the Annals which contains the positions of variables in clusters and of their comparison stars. For Eros, the asteroid of special significance, offering as it does one of the keys to solar parallax, she made lengthy calculations in order to predict its path for future years and thus further its observation at the opposition of 1903. She computed a circular orbit for the asteroid Ocllo, discovered at Harvard's southern station, Arequipa, Peru, and later assisted Dr. Newcomb in determining its elliptical elements which brought out the interesting fact that of all asteroids, its path about the Sun deviates most widely from a circle.

Miss Winlock's most important, independent investigations are to be found, perhaps, in the four memoirs connected with her name. Taken together they constitute the most complete catalogue of stars near the north and south poles, so far attempted. Parts 9 and 10 of volume XVIII of the Annals are based upon the meridian circle, and include all the observations, taken with it or like instruments, of 52 stars within one degree of the north pole, and of 26 stars within two degrees of the south pole, respectively. Part 9 treats of the method of Fabritius to be employed, and gives the table especially prepared for precession and secular variation of co-ordinates which are used in both parts. The materials were gathered from scores of different authorities, distributed over a century and a half, discussed and marshaled so as to present in convenient form not only the position and proper motions deduced, but also all the data for these results given by the old astronomy. The other two parts of what may be called this general polar catalogue contain a much larger number of stars and depend upon photographs of regions about the poles. The last one, dealing with the south pole, has not yet been published. It was her last astronomical work.

As to her father and brother, death came suddenly to Anna Winlock. Toward the close of last year, she was not quite so well as usual, being troubled with a cold. She gave little thought to it, however, going on with her varied duties at home and at the observatory, writing letters to friends and sending

away tokens of Christmas remembrance. On December 17, though she little realized it, she went up to Harvard College Observatory for the last time. Her record there of more than twenty-eight years was closed. Still she worked on a little longer. The last entry in her current note-book of reductions is December 28, and on New Year's day she had notes on the "south polar catalogue" and other astronomical papers beside her on the bed. Her death came three days later, and in St. John's chapel, endeared to her by family associations and many years of worship, less than two weeks after her last attendance there, her funeral service was held.

To friends and kindred she leaves a rich legacy simply by having lived. Her delicate sense of humor gave a very human touch to a nature too spiritual and too intellectual to be understood by all. Her gentle loving kindness veiled in part the power of her intellect. Doubtless many knew her without realizing how far beyond the average were her powers of mind. She seemed not to realize it herself. For a little thing that others did she was prodigal with hearty praise while she quietly, but persistently ignored real achievements of her own.

Most of the lines in the sonnet to Joseph Winlock, by James Russell Lowell, are as true of the daughter as of the father. She too was,

> "Careless of fames that Earth's tin trumpets fill"
> Strong of soul and "patient of Will" she labored
> "Through years one hair's breadth on our
> Dark to gain."

VARIABILITY OF IRIS (7).

EDWARD C. PICKERING.

A series of measurements of the light of the planet Iris (7) has been made by Professor Wendell with the polarizing photometer, with sliding achromatic prisms, attached to the 15-inch equatorial telescope of the Harvard College Observatory. A variation like that of the planet Eros has been established, having a period of about $0^d.259 = 6^h\ 13^m$. The range is only two or three tenths of a magnitude, and the variation would be uncertain but for the very small accidental errors which occur in observations made in this way. See Circulars Nos. 23, 25, 30 and 41.

The results of the measures made by Professor Wendell are given in Table I. The Julian Day and fraction following Green-

wich Mean Noon, omitting the three left hand figures, 241, is given in the first column. The designation of the comparison star is given in the second column. The observed difference in magnitude between Iris and the comparison star is given in the third column, a positive sign indicating that the star was brighter than Iris. The fourth column gives the phase computed by the formula $2{,}416{,}470^d.000 + 0^d.259$ E. The fifth column gives the amount that Iris is fainter than its assumed maximum magnitude. This quantity was found by plotting the times and observed differences in magnitude on each night, and by inspection assuming the maximum magnitude. The latter was then subtracted from the observed magnitude, and a curve constructed from these differences and the corresponding phases. Owing to errors in the assumed maximum magnitudes, the points on some nights were above and on others below the curve. The mean value of the deviations from the curve for each night was therefore subtracted from these differences and gives the quantity contained in the fifth column. Negative signs are indicated by italics. This process was necessary, since different stars were used on different nights, and we had no means of knowing their true magnitudes. The sixth column gives the residual found by subtracting the magnitude as given by a smooth curve from that contained in the fifth column. The average value of these 46 residuals is only $\pm$ 0.022.

TABLE I.

OBSERVATIONS OF IRIS (7).

J. D.	DM.	Diff.	Phase.	M.	O—C.
6475.606	+18° 1576	— 0.79	0.167	0.22	0.03
" .612	" "	0.86	0.173	0.15	*0.02*
" .658	" "	1.01	0.219	0.00	*0.01*
" .665	" "	1.02	0.226	*0.01*	*0.02*
6477.645	+18° 1553	0.96	0.134	0.06	*0.02*
" .651	" "	0.90	0.140	0.12	0.02
" .662	" "	0.86	0.151	0.16	0.00
6479.603	+18° 1538	+ 0.12	0.020	0.21	0.02
" .611	" "	+ 0.11	0.028	0.20	*0.01*
" .656	" "	— 0.02	0.073	0.07	0.04
" .664	" "	0.07	0.081	0.02	0.00
6480.552	" "	0.08	0.192	0.05	*0.02*
" .558	" "	0.13	0.198	0.00	*0.04*
" .586	" "	0.07	0.226	0.06	.05
" .612	" "	0.07	0.252	0.06	*0.01*
" .621	" "	0.04	0.002	0.09	*0.03*
6485.565	+18° 1496	1.66	0.025	0.25	0.04
" .570	" "	1.68	0.030	0.23	0.02
" .601	" "	1.83	0.061	0.08	0.00
" .606	" "	1.91	0.066	0.00	*0.04*
" .624	" "	1.88	0.084	0.03	0.01
" .631	" "	1.90	0.091	0.01	*0.01*
" .651	+" "	— 1.86	0.111	0.05	0.00

TABLE I.—CONTINUED.

OBSERVATIONS OF IRIS (7).

J. D.	DM.	Diff.	Phase.	M.	O—C.
6485.660	+ 18 1496	— 1.83	0.120	0.08	0.02
6487.540	+ 18 1495	1.68	0.187	0.10	0.00
" .546	" "	1 72	0.193	0.06	0.00
" .568	" "	1.76	0.215	0.02	0.01
" .576	" "	1.76	0.223	0.02	0.01
" .599	" "	1.73	0.246	0.05	0.00
" .606	" "	1.75	0.253	0.03	*0.04*
" .627	" "	1.64	0.015	0.14	*0.04*
" .636	" "	1.59	0.024	0.19	*0 02*
" .656	" "	1.68	0.044	0.10	*0.03*
" .664	" "	1.71	0.052	0.07	*0.01*
5495.567	+ 18 1419	1.00	0.185	...	...
" .574	" "	1.02	0.192	...	...
6498.543	+ 18 1391	1.99	0.053	0.08	0.00
" .551	" "	2.04	0.061	0.03	*0.02*
6499.524	" "	1.82	0.257	0.21	0.10
" .530	" "	1.82	0 004	0.21	0.07
" .546	" "	1.80	0.020	0.23	0.03
" .552	" "	1.82	0.026	0.21	0.00
" .578	" "	1.96	0.052	0.07	*0.01*
" .585	" "	1.97	0.059	0.06	0.00
" .603	" "	2.01	0.077	0.02	0.00
" .610	" "	2.08	0.084	*0.05*	*0.07*
" .630	" "	2.03	0.104	0.00	*0.03*
" .660	+ 18 1391	— 1.96	0.134	0.07	*0.03*

TABLE II.—LIGHT CURVE.

Ph.	M.	Ph.	M.	Diff.
0.00	0.12	0.13	0.09	0.03
0.01	0.16	0.14	0.12	0.04
0.02	0.19	0.15	0.17	0.02
0.03	0.21	0 16	0.19	0.02
0.04	0.17	0.17	0.18	*0.01*
0.05	0.10	0.18	0.14	*0.04*
0.06	0.05	0.19	0.09	*0.04*
0.07	0.03	0.20	0.06	*0.03*
0.08	0 02	0.21	0.02	0.00
0.09	0.02	0.22	0.01	0.01
0.10	0.03	0.23	0.02	0.01
0.11	0.04	0.24	0.03	0.01
0.12	0.06	0.25	0.03	0.03

The cöordinates of the light curve are given in Table II. The phases are given in the first and third columns, the corresponding magnitudes in the second and fourth columns. The differences found by subtracting the numbers in the fourth column from those in the second are given in the fifth column. It will be seen therefore that there are two maxima and two minima, which are so nearly equal that it is as yet impossible to say whether the differences are real or due to small systematic errors. In the latter case, the period should be divided by two, and become $0^d.1295 = 3^h\ 6^m$.

It will be seen that the variation closely resembles that of Eros, and that the conditions discussed in Circular No. 58, apply to

Iris also. The latter asteroid is bright enough to be readily observed during a large part of the time, but unfortunately the change of light is now so small that it can be determined only by observations in which the accidental errors are extremely small. In fact, the observations of Iris made at Potsdam in 1884 (Publicationen, VIII, 294) fail to show this variation, either because the range was then too small, the period was then different, or the errors of observation rendered the variation imperceptible. The average of the residuals on the twenty-six nights of observation was $\pm$ 0.073, or about the same as that for the other asteroids. A change in the period seems improbable.

The observations contained in Table III were made on January 25, 1904, after the above discussion was completed. Iris was compared with + 17° 1404, and the Julian Day and fraction, difference in magnitude, and phase, are given in the successive columns. It will be seen by plotting these observations, that they fall almost exactly upon a smooth curve and that the phase of maximum, $0^d.085$, agrees very nearly with that derived from the previous observations. A change, however, appears to have taken place in the range which now exceeds three-tenths of a magnitude, or an increase of about one-half in a few days. This change is confirmed by the last ten residuals in the last column of Table I, which indicate that the increase in range occurred between J. D. 6487 and J. D. 6499. The change in the range of Eros in the spring of 1901 was also much more rapid than might have been expected from geometrical considerations. The range on March 12, 1901, was found to be about 1.0, on April 12, 1901, 0.4, and on May 6 and 7, 1901, 0.0, magnitudes.

TABLE III.

LATER OBSERVATIONS.

J. D.	Diff.	Ph.
6505.539	— 0.52	0.056
" .546	0.56	0.063
" .562	0.59	0.079
" .569	0.60	0.086
" .585	0.58	0.102
" .592	0.56	0.109
" .610	0.44	0.127
" .619	0.37	0.136
" .636	0.28	0.153
" .645	0.34	0.162
" .656	0.38	0.173
6505.662	— 0.46	0.179

Evidently, this object should be watched carefully. It is now favorably situated, as it is approaching its second stationary point, and is of about the eighth magnitude. Iris can be con-

veniently compared photometrically with the stars + 17° 1339, + 17° 1355, + 17° 1364, and + 17° 1391, during the next few weeks, and it is hoped that observers elsewhere will connect their observations with these stars and with the comparison stars used in Tables I and III, so that all may be reduced to one system. Measures of the absolute magnitudes of these stars will be undertaken here. It will be noticed that observations on each night should extend over at least three hours. In that case, a maximum and minimum will always be included, so that the absolute magnitudes of the comparison stars will be of less importance.—From *Harvard College Observatory, Circular No. 75.*

January 27, 1904.

CHARLES HALL ROCKWELL.

W. W. PAYNE.

We have waited longer than previously planned to pay a deserved tribute, in this publication, to the memory of our long known and esteemed friend, the late Charles H. Rockwell. His relatives and many friends will kindly overlook this in us, when we say that it seemed fitting to wait unusually and unexpectedly long for the engraver to do his work well, that all who read the mute words of these pages might once more look on the familiar features of that expressive face, that holds us all, now, heart to heart in thoughtful mood, as a cherished friend has bidden his adieu, and closed on Earth a happy and a most useful life.

Charles H. Rockwell was born at Hartford, Conn., July 17, 1826, and died at Tarrytown, N. Y., Jan. 1, 1904. His youth was spent at Norwich in the same state. In 1843 he entered the laboratory of Professor Benjamin Silliman of Yale College for instruction in chemistry. It is noteworthy that young Rockwell chose one of the best places, if not the very best, for instruction in this important branch of study at that time.

Professor Silliman was then an authority in chemistry, and was also the founder of a very strong journal in that science which has borne his name from that day to this. At that time he made the acquaintance of A. D. Stanley, Professor of Mathematics, who directed his attention to the application of mathematics to astronomical work, and thus determined the bent of his mind that afterwards controlled so large a part of Mr. Rockwell's life.

In 1850 he made a voyage to California around Cape Horn,

and by this means, received instruction in navigation and became skillful in the use of the sextant. While in California and residing at San Francisco, he improved the opportunity in making frequent visits to the Observatory of the Coast Survey, located at that place, to gain information about the use of astronomical instruments.

Later his marriage, the loss of his wife and child, and his services during the Civil War brought him to the year 1866. In 1869 he established himself at Tarrytown, New York, and at that place he built a small astronomical observatory, and entered on the work of an amateur astronomer, which calling seemed to be the delight of his life, and the wide circle of scientific friends it made for him were highly prized and worthily kept during his life.

He procured only the best astronomical instruments for his own Observatory, in the latest and most approved patterns considering the size adapted to the work for which they were to be used. As an instance of this we call to mind his lively interest in Professor S. C. Chandler's new instrument, devised years ago, which goes by the name of the Almucantar. Mr. Rockwell quickly saw the superior advantages of it, and was the first, if we remember rightly, to place an orde r for it for his Observatory.

Outside of his own Observatory, the total solar eclipse was one of the most absorbing themes in practical astronomy that engaged Mr. Rockwell's attention. He was often found in the expeditions of prominent astronomers in the United States, or, in planning and conducting those of his own to remote parts of this country. A single incident will serve to illustrate his interest in, and close attention to, these rare opportunities for the study of unknown and very difficult solar phenomena. The prediction for the total solar eclipse of 1883, gave a portion of the path of totality in the south Pacific Ocean. Because the narrow band of shadow crossed no prominent islands, little attention was given to it. As the time of the eclipse was approaching, Mr. Rockwell examined its path carefully, and was the first, in this country, to notice that it would pass over that insignificant, rock reef, nine miles long by one mile wide, known by the name of Caroline Island, at a favorable time for observation. This fact he made known to astronomers, and as a result, an expedition of experienced observers including Mr. Rockwell was formed and, on May 6, 1883, the desired observations were successfully made. New information concerning the solar corona, was the chief feature of this expedition.

Other similar expeditions in which Mr. Rockwell had a part were the solar eclipse of 1878, Colorado; 1881, Transit of Mercury, Honolulu; 1889, solar eclipse, California, and 1889, the solar eclipse, Cayenne, South America. The last named expedition was from Lick Observatory, and Mr. Rockwell assisted in the photographic work. It was reported that all the plates turned out well. The curved rays of the corona came out beautifully on some of the plates, which was a thing of special interest as mentioned by Mr. Rockwell in a private letter to the editor of the *Sidereal Messenger* extracts from which were published in that magazine, Vol. IX. 1890, p. 94.

An expedition to the Hudson's Bay Company's station at Moose Factory in the summer of 1880 is worthy of mention. A party was formed comprising Dr. George W. Hill, Lieut. S. W. Very of the Navy and Mr. Rockwell, and starting from Lake Superior it followed the well known trade route up the Michipicotton River and down the Moose River to Hudson's Bay and returned by the same route. Lieut. Very was the astronomer of the party, Dr. Hill the topographer and Mr. Rockwell the quarter master and general director. Good observations for latitude and longitude were made both going and coming, and Dr. Hill has embodied the results in an excellent map which remains in manuscript in his hands awaiting the appearance of some public spirited friend who will provide funds for its publication.

We have already spoken briefly of Mr. Rockwell's interest in the new instrument devised by Professor S. C. Chandler, known as the Almucantar. At the Minneapolis meeting of the American Association for the Advancement of Science, in 1880, Professor Chandler presented a paper showing the construction of the instrument and the methods of its use. The paper was published in Vol. 2 of the *Sidereal Messenger*, p. 269. In that paper reference was made to some results obtained by the new instrument in the determination of latitude that were surprisingly accurate for one so small as that which was used. It readily detected errors that seemed to have been troublesome with larger and more expensive instruments. In that paper only the merest reference was made to its use in determining time, although its effectiveness might be inferred from the precise results obtained in latitude work. In Vol. 3 of the *Sidereal Messenger*, page 285, will be found a reference to Mr. Rockwell's work with the Almucantar. The results of his observations for time are there given, and they are for four consecutive days remarkably close, the pairs of stars varying only in hundredths of seconds of time.

PLATE IX

CHARLES HALL ROCKWELL

1826-1904

In his latitude work Mr. Rockwell's attention was called to a discrepancy in the results obtained from the same stars, after an interval of three years. He communicated the fact to Professor Chandler who found in his observations material to aid in detecting the complex motion of the geographical pole of the Earth, which has occupied the attention of astronomers so much during the last few years, and in which Professor Chandler has been a brilliant leader in the mathematical and theoretical investigation of this difficult problem.

In the pursuit of an accurate time-piece Mr. Rockwell devised a pendulum which he believed had points of excellence that he desired to test thoroughly. About the same time his friend, J. H. Gerry, of Brooklyn, N. Y., had thought out another, and invited a contest between the two. To this end Mr. Gerry constructed two clocks, as nearly identical as he could make them, and attached one of the rival pendulums to each and they were started in competition. In August 1898, a few months later, Mr. Rockwell had an attack of paralysis which rendered him incapable of continuing the work, and it was taken up and carried to completion by his brother.

Apart from that portion of his life which was more or less of public interest, Mr. Rockwell's life was filled with private benefactions that endeared him to a host of friends. Among these that have had a wide influence in science and public life is the assistance rendered to J. E. Keeler, that brought him, a boy in obscure life on the sands of Florida, and started him on a career that placed him, when in his prime of life among the most noted of astronomers in the world. Some of Mr. Rockwell's friends have well said, if he had only done this one good deed in his life, it would entitle him to a place on the roll of fame.

Mr. Rockwell's life was many sided; he was at home among sportsmen, travelers, geographers, sailors and astronomers, and popular with them all.

TRAILS OF STARS NEAR THE NORTH POLE.

W. W. PAYNE.

The frontispiece to this number of POPULAR ASTRONOMY is a reproduction of a photograph taken by Dr. H. C. Wilson in December, 1903, by the aid of the Brashear 6-inch camera which is attached to the 8¼-inch equatorial of Goodsell Observatory for the sake of the driving apparatus connected with that telescope

for ordinary work. In this particular photograph no clock-work was needed, as most readers will readily understand when it is stated that the central part of the picture represents the position of the north celestial Pole of the heavens.

To get the effect shown in this picture, the photographic camera was carefully pointed to the pole and permitted to remain undisturbed for the length of exposure desired. In this instance, the exposure began at 6 o'clock in the evening, and it was continued until 6 o'clock the next morning. If the reader will notice carefully, the trails of the brightest stars are beautifully continuous in width throughout the twelve hours until near the end, at which place they are broken up into dots and dashes, some of the latter of which are sharply pointed in the original negative. The meaning of the broken curves at the end is that clouds interfered with the exposure near the last of it.

It is also noticeable that there are very faint stars quite near the Pole as their trails appear as very small semi-circles around the middle point of the figure. The bright trail three-fourths of an inch from the center is the path of Polaris, and the strong trails further away are the bright stars of the Great Dipper. The picture is an interesting one for the number of star trails shown and also for the length of uninterrupted exposure given to it. In this latitude it would not be possible to expose this region of the sky in one night more than fourteen hours. It is deemed a rare opportunity to get twelve good consecutive hours for photographic work in any one night during any time of the year.

Another interesting thing which Dr. Wilson hoped to bring out by this long exposure, was the detection of variable stars, if such there were in this region. It will be readily understood that if any star trail on the plate should show a broadening or narrowing in any part that would suggest rapid variation and lead to careful study of such stars to learn certainly if they were or were not variable stars. We have not found variation in the trails as far as examined. The exposure of this region for twelve hours, is one of the longest, if not the longest, as far as we know.

THE NUMBER OF THE STARS.

GAVIN J. BURNS, B. Sc.

For Popular Astronomy.

Various estimates of the number of stars of each magnitude have been made by astronomers. One of these estimates will be found on p. 506 of vol. IX of Popular Astronomy. But, till recently, owing to the lack of trustworthy data, all such estimates have been very rough. The progress that has been made in recent years in stellar photometry, and the work lately done in the preparation of the Astrographic Chart enable us to form a better idea of the number of the stars than has hitherto been possible.

The Harvard Photometrics give a complete list of all stars down to the sixth magnitude. According to those photometrics, there are

38	stars	under	magnitude	2
99	"	from	"	2 to 2.99
317	"	"	"	3 " 3.99
1020	"	"	"	4 " 4.99
2865	"	"	"	5 " 5.99

There is at present no complete list of stars from magnitude 6 to 6.99. The Harvard Photometric Durchmusterung contains all stars to magnitude 7.5 and within 130° of the N. pole. The number of stars from 6 to 6.99 given in this catalogue is 7848 according to W. Gore, from which he estimates the number for the whole sphere at 9554, by assuming them to be uniformly distributed.* I believe a somewhat better estimate can be obtained in the following manner. The number of stars in the H. P. D. brighter than the 6th magnitude is 3749, while the total number, according to the Harvard Photometrics, is 4339. Then, assuming a uniform ratio of stars under the sixth magnitude to stars under the seventh magnitude, we get the following proportion:

$$3749 : 4339 :: 7848 : 9082.$$

This will give a total of stars brighter than the seventh magnitude of 13421, (say 13,400).

For stars from the seventh to the ninth magnitude, we have to base our estimate on the Bonn Durchmusterung. The number of stars under the seventh magnitude in the Northern hemisphere is 5876 according to the B. D., whereas the total, as we have

* *Journal of British Astronomical Association*, XII. 128.

seen, is about 13400. By assuming that the ratio is the same for stars of fainter magnitudes, we get the following figures:

	No. of stars in B. D.	Estimated total.
Under mag. 7	5,876	13,400
" " 8	19,699	45,000
" " 9	77.794*	177,000

It is here assumed that the scale of magnitude in the B. D. is the same as the photometric scale. As the H. P. D. gives the magnitudes of many stars of the 8th and 9th magnitude, a comparison can be made between the scales. An examination of the magnitudes of such stars shows that, although in individual cases, the magnitudes differ widely, yet, on an average, the two scales are nearly the same.

With respect to stars fainter than the 9th magnitude, our knowledge is very indefinite. The most recent information is contained in a paper giving "Statistics of stars in a zone of 5° from + 65° to + 70° decl. counted on photographs for the Astrographic Chart and Catalogue at the Royal Observatory, Greenwich."† This paper gives an enumeration of 229426 stars. The following is a summary of the results:

No. in B. D. of 9th mag. and brighter	3094
No. shown on photographs in duplicate with an exposure of 20^s	6663
No. shown on photographs in duplicate with an exposure of 3^m	38262
No. shown on photographs in duplicate with an exposure of 40^m	199776

The above figures all refer to the zone mentioned above.

"On the assumption that an equal total amount of light produces an equal photographic effect, an additional magnitude is reached by increasing the exposure 2.5 times. Between the 3^m and 20^s (ratio 9 to 1) there corresponds a difference of magnitude of 2.38. Between the 40^m and 20^s exposure (ratio 120 to 1) there is a difference of 5.20. If r be the ratio of the number of stars down to magnitude $m + 1$ to the number down to magnitude m, we obtain

$$\left.\begin{aligned} r^{2.38} &= 4.29 \text{ from the } 20^s \text{ and } 3^m \text{ images.} \\ r^{5.20} &= 29.58 \text{ from the } 20^s \text{ and } 40^m \text{ images.} \end{aligned}\right\}$$

Thus from the 20^s and 3^m images, we get $r = 1.84$
and from the 20^s and 40^m images, we get $r = 1.92$"

* From a table given by J. J. Plummer, in *Monthly Notices*, XXXVII, 436.

† *Monthly Notices*, Jan. 1903.

The zone on which these values of r are based is about 1/60th of the whole sky. Probably the average value of r does not differ much from the values above found. Assuming $r = 1.9$, and the number of stars under the 9th magnitude = 177000, we get the following figures:

Total number of stars under mag. 9	177,000
" " " " " 10	336,000
" " " " " 11	639,000
" " " " " 12	1,214,000
" " " " " 13	2,306,000
" " " " " 14	4,382,000
" " " " " 15	8,325,000

The following table gives a summary of the results:

Magnitude.	Number.	Total.	r
Under 2	38	—	—
2 and under 3	99	137	3.6
3 " " 4	317	454	3.3
4 " " 5	1,025	1,474	3.2
5 " " 6	2,865	4,339	2.9
6 " " 7	9,082	13,421	3.1
7 " " 8	31,579	45,000	3.4
8 " " 9	132,000	177,000	3.9
9 " " 10	159,000	336,000	1.9
10 " " 11	303,000	639,000	1.9
11 " " 12	575,000	1,214,000	1.9
12 " " 13	1,092,000	2,306,000	1.9
13 " " 14	2,076,000	4,382,000	1.9
14 " " 15	3,943,000	8,325,000	1.9

The numbers in the last column are the ratios of the successive totals. It will be noted that there is a sudden drop in the value of this ratio at the 10th magnitude. It might be supposed that this is due to the change in the method of determining magnitudes, which have been ascertained by eye observations from magnitudes 1 to 9, and by photography from 10 to 15. Some visual observations of my own, however, are quite in accordance with the figures given in the table. As the result of 122 gaugings taken in various parts of the sky, I found that the number of stars visible with a ¾-inch aperture, and the number visible with a 3-inch aperture is nearly in the ratio 3.40. Now, a ratio of 1.4 in aperture represents just 3 magnitudes, and a ¾-inch aperture shows stars to the 8th magnitude or somewhat fainter. The ratio shown in the table for magnitudes 8 and 11 is 3.42. The closeness of this agreement shows that there is a real drop in the value of r at about the 10th magnitude, and that it is not due to errors of observation.

Assuming that the stars are uniformly distributed throughout space, it may be readily shown that $r = 4$. The fact that r is always less than 4, and that its value diminishes for the fainter

magnitudes, is strong presumptive evidence that the stars thin out as their distance from our system increases.

ON THE SIX YEARS' CYCLE OF THE POLAR MOTION DURING THE INTERVAL 1891-1902.*

H. KIMURA.

During the study of the polar motion, I have found that the returns of the same phases (not the amplitudes) in the motion of the pole at the same epochs of the year during the interval 1890-1902 take place in six years. This interesting fact is seen at a glance on the accompanying diagram, in which the values of the two components, x and y, are taken from those given by Professor Albrecht, those for the epochs before 1899.8 being corrected throughout by the same ξ given in my paper A. N. 3783. The diagram also shows that the maximum deviations of the instantaneous pole occurred in 1891 and 1897, and the minimum, in 1894 and 1900. Thus it might be inferred that the next maximum and minimum will come in 1903 and 1906 respectively.

If we assume the existence of a certain principal annual term in the polar motion, the above fact indicates that the other term will have a period of 438 days. Under this consideration, I have found, by successive approximations, the following expressions of x and y for the two epochs:

I. Epoch, 1890.0-1896.0.

$$x = -0''.145 \cos((t - 1894.73) \times 300^\circ) + 0''.014 \sin \odot - 0''.130 \cos \odot$$

$$y = +0''.145 \sin((t - 1894.73) \times 300^\circ) + 0''.070 \sin \odot + 0''.027 \cos \odot$$

II. Epoch, 1896.0-1902.0.

$$x = -0''.145 \cos((t - 1894.73) \times 300^\circ) + 0''.013 \sin \odot - 0''.085 \cos \odot + 0''.008$$

$$y = +0''.145 \sin((t - 1894.73) \times 300^\circ) + 0''.051 \sin \odot + 0''.002 \cos \odot + 0''.009$$

where t is expressed in the units of a year, and $\odot$ is the longitude of the Sun.

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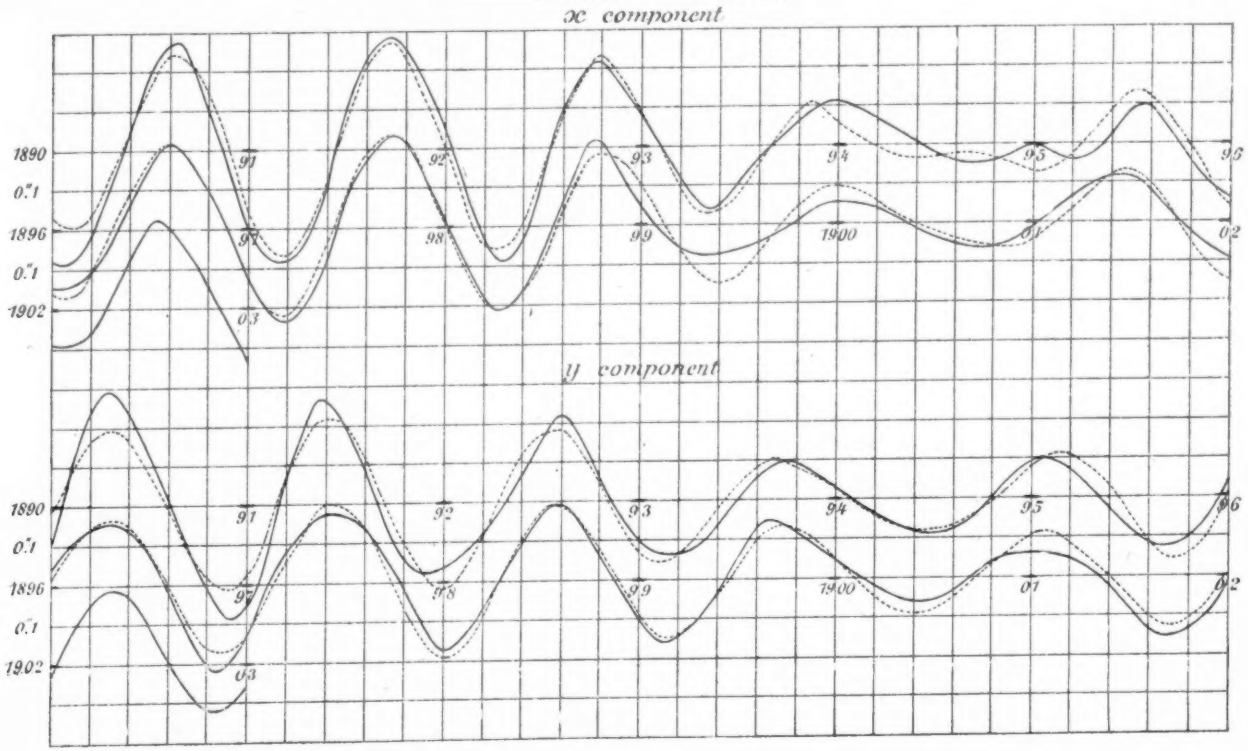
* From *Astronomische Nachrichten*, No. 3932.

CURVES OF THE COMPONENTS OF THE POLAR MOTION.
———OBSERVED.....COMPUTED.



For the sake of easy comparison, the calculated values are also given in the diagram by the dotted curves, which lie closely to those plotted from the observation. The approximate coincidence of these two series of curves for x and y, shows that the polar motion may be pretty well represented by the combinations of two terms of the periods 438^d and 365^d.

On close examination, we find, however, that the sizes of the axes of the annual ellipse vary from year to year, the law of variation being not of a simple character; while the phases remain sensibly the same. Such irregular variations of annual ellipse might generally be attributed to some causes, whose phases are always nearly the same, but whose amplitudes differ for different years, as for instance the meteorological conditions at every place on the Earth. It is, further, to be remarked that the inaccuracies in the value of ξ and the aberration constant affect the annual terms slightly.

While I was occupied with the preceding investigation, I have noticed from the series of observations at each station, that there exists some systematic variation of considerable amount, which can by no means be regarded as of a general character but only of a local. The components x and y, determined from the observations at only a few stations, might have the share of systematic errors peculiar to the localities as well as the observers, the instruments, and the stars observed.

MIZUSAWA, International Latitude Station,
1903 November 6.

PLANET NOTES FOR MAY.

H. C. WILSON.

Mercury will be at inferior conjunction on the morning of May 13, and so will be invisible to the eye during this month.

Venus may be seen in the east an hour before sunrise, and is slowly drawing nearer to the Sun. The disk of the planet is nearly full, but the brightness is near the minimum, because of the great distance at which the planet is seen as well as the glare of the solar rays. On May 22 at 9 A. M., C. S. T., Mercury and Venus will be in conjunction, Mercury being on the nearer side of his orbit while Venus is on the farther side from the Earth. The two are not then in favorable position for observation but it may be possible to see them with the aid of a telescope. At the time of conjunction Mercury will be nearly two degrees south of Venus.

Mars is too close to the Sun for observation, and is on the farther side of his orbit. On May 9 at 4 P. M., C. S. T., Mars and Mercury will be in conjunction

and only 21′ apart in declination, but they cannot be seen even with a telescope at this time. Mars will be at conjunction with the Sun May 30.

THE CONSTELLATIONS AT 9 P. M. MAY 1, 1904.

Jupiter is morning star, and, during the latter days of the month, will be far enough out from the Sun, for those who wish to study its surface markings as continuously as possible to begin their observations.

Saturn will be at quadrature, 90° west from the Sun, May 11 and so may be observed in the morning hours. Look toward the southeast in the constellation Capricorn. There are no stars as bright as Saturn in that vicinity.

Uranus may also be observed in the morning, with the aid of a telescope, in the Milky Way north of γ and west of λ Sagittarii.

Neptune is the only planet observable in the evening, and it will soon be too

low in the west for satisfactory study. For its position see the chart in the March number of POPULAR ASTRONOMY, page 202.

The Moon.

	Phases.	Rises. (Central Standard Time at Northfield. Local Time 13m less.)	Sets.
1904		h m	h m
May 7	Last Quarter	1 11 A. M.	11 45 A. M.
15	New Moon	5 14 "	7 51 P. M.
21-22	First Quarter	10 58 "	12 54 A. M.
28-29	Full Moon	7 05 P. M.	5 06 "

Occultations Visible at Washington.

Date. 1904.	Star's Name.	Magnitude.	IMMERSION. Washington M. T. h m	IMMERSION. Angle from N pt. °	EMERSION. Washington M. T. h m	EMERSION. Angle from N pt. °	Duration. h m
May 1	24 Scorpii	5.2	9 17	81	10 17	308	1 00
8	67 Aquarii	6.2	13 56	3	14 16	327	0 20
19	1 Cancri	5.9	7 45	90	8 46	301	1 01
21	B.A.C. 3398	6.0	10 50	164	11 24	236	0 34
26	B.A.C. 4772	6.6	7 31	161	8 21	246	0 50
26	B.A.C. 4828	6.0	14 48	65	15 37	318	0 49
27	o^2 Libræ	6.3	9 8	149	10 10	252	1 2
30	Y Sagittarii	Var.	16 38	8	16 58	238	0 20

ASTEROID NOTES.

Naming of Asteroids.—The following small planets have recently been named:

No.	Provisional Designation.	Name.	No.	Provisional Designation.	Name.
(360)	1893 N	Carlova	(484)	1902 HX	Pittsburghia
(456)	1900 FH	Abnoba	(488)	1902 JG	Kreusa
(462)	1900 FQ	Eriphyla	(493)	1902 JS	Griseldis
(482)	1902 HT	Petrina	(503)	1903 LF	Evelyn
(483)	1902 HU	Seppina	(507)	1903 LO	Laodica

New Asteroids.—The following have been added to the list of new planets since our last note:

	Discovered by	at	Local M. T.	h m	R. A. h m	Decl. ° ′	Mag.
1904 ND	Dugan	Heidelberg	Jan. 27	15 30.2	8 32.1	+ 13 47	11.8
1903 NE	Hirayama	Tokyo	Nov. 26	12 55	4 11.9	44 17	12
1903 NF	Peters	Washington	Dec. 15	11 27.7	5 42.0	9 20	...
1903 NG	Götz	Heidelberg	Oct. 27	14 21.9	3 14.9	19 13	13.0
1904 NH	Charlois	Nice	Feb. 15	9 52.0	9 3.7	+ 18 18	10.5

1904 NA has been found to be identical with (505) [1902 LL] and NH is also identical with (200) Dynamene.

VARIABLE STARS.

Minima of Variable Stars of the Algol Type.

[Greenwich Mean Time beginning with noon.]

U Cephei.

	d	h
May	1	22
	4	10
	6	22
	9	10
	11	21
	14	9
	16	21
	19	9
	21	21
	24	9
	26	21
	29	8
	31	20

R Canis Maj.

	d	h
May	2	2
	3	5
	4	8
	5	12
	6	15
	7	18
	8	21
	10	1
	11	4
	12	7
	13	10
	14	14
	15	17
	16	20
	18	0
	19	3
	20	6
	21	9
	22	13
	23	16
	24	19
	25	22
	27	2
	28	5
	29	8
	30	11
	31	15

RR Puppis.

	d	h
May	2	16
	9	2
	15	13
	21	23
	28	9

V Puppis.

	d	h
May	1	5
	2	16
	4	3
	5	14
	7	1
	8	12
	9	23
	11	10
	12	21
	14	8
	15	19
	17	5
	18	16
	20	3
	21	14
	23	1
	24	12
	25	23
	27	10
	28	21
	30	8
	31	18

S Cancri

	d	h
May	1	18
	11	6
	20	18
	30	5

S Antliæ.

Period $7^h\ 46^m.8$.

	d	h
May	1	4
	2	3
	3	3
	4	2
	5	1
	6	1
	7	0
	7	23
	8	23
	9	22
	10	21
	11	21
	12	20
	13	19
	14	19
	15	18
	16	17
	17	17
	18	16
	19	16
	20	15
	21	14
	22	14
	23	13
	24	12
	25	12
	26	11
	27	10
	28	10
	29	9
	30	8
	31	8

S Velorum.

	d	h
May	4	10
	10	8
	16	7
	22	5
	28	4

W. Urs. Maj.

Period $4^h\ 0^m.2$

May 1-31 7^h

RR Velorum.

	d	h
May	2	9
	4	5
	6	2
	7	22
	9	19
	11	15
	13	12
	15	8
	17	5
	19	1
	20	22
	22	18
	24	15
	26	11
	28	8
	30	4

Z Draconis.

	d	h
May	1	7
	2	15
	4	0
	5	8
	6	17
	8	2
	9	10
	10	19
	12	3
	13	12
	14	20
	16	5
	17	14
	18	22
	20	7
	21	15
	23	0
	24	8
	25	17
	27	2
	28	10
	29	19
	31	3

δ Librae.

	d	h
May	2	10
	4	18
	7	2
	9	10
	11	17
	14	1
	16	9
	18	17
	21	1
	23	9
	25	17
	28	0
	30	8

U Coronae.

	d	h
May	1	23
	5	10
	8	21
	12	8
	15	18
	19	5
	22	16
	26	3
	29	14

R Araæ.

	d	h
May	4	2
	8	12
	12	22
	17	8
	21	19
	26	5
	30	15

U Ophiuchi.

	d	h
May	1	15
	2	12
	3	8
	4	4
	5	0
	5	20
	6	16
	7	12
	8	8
	9	5
	10	1
	10	21
	11	17
	12	13
	13	9
	14	5
	15	2
	15	22
	16	18
	17	14
	18	10
	19	6
	20	2
	20	22
	21	19
	22	15
	23	11
	24	7
	25	3
	25	23
	26	19
	27	15
	28	12
	29	8
	30	4
	31	0
	31	20

Z Herculis.

	d	h
May	3	0
	4	21
	6	23
	8	20
	10	23
	12	20
	14	23
	16	20
	18	23
	20	20
	22	23
	24	20
	26	22
	28	20
	30	22

RS Sagittarii.

	d	h
May	1	23
	4	9
	6	19
	9	5
	11	15
	14	1
	16	11
	18	21
	21	7
	23	17
	26	3
	28	13
	30	23

RX Herculis.

	d	h
May	1	2
	1	23
	2	21
	3	18
	4	15
	5	13
	6	10
	7	7
	8	5
	9	2
	9	23
	10	21
	11	18
	12	15

Minima of Variable Stars of the Algol Type.—Continued.

RX Herculis.			RV Lyræ.			SW Cygni.			V VCygni.			Y Cygni.		
	d	h		d	h		d	h		d	h		d	h
May	13	13	May	18	2	May	15	5	May	4	22	May	1	18
	14	10		21	17		19	20		6	9		3	3
	15	7		25	7		24	9		7	21		4	18
	16	5		28	21		28	23		9	8		6	3
	17	2	U Sagittæ.			UW Cygni.				10	19		7	17
	17	23	May	2	1	May	4	2		12	7		9	2
	18	21		5	10		7	13		13	18		10	17
	19	18		8	20		11	0		15	6		12	2
	20	15		12	5		14	11		16	17		13	17
	21	13		15	14		17	21		18	5		15	2
	22	10		18	23		21	8		19	16		16	18
	23	7		22	8		24	19		21	4		18	2
	24	5		25	17		28	6		22	15		19	17
	25	2		29	2		31	17		24	3		21	2
	25	23	SY Cygni.			W Delphini.				25	14		22	17
	26	21								27	1		24	2
	27	18	May	1	17	May	1	5		28	13		25	17
	28	16		7	17		6	0		30	0		27	2
	29	13		13	17		10	20		31	12		28	17
	30	10		19	17		15	15					30	2
	31	8		25	18		20	10					31	17
				31	18		25	6	VW Cygni.					
RV Lyræ.			SW Cygni.				30	1				UZ Cygni.		
May	3	17	May	1	12	VV Cygni.			May	9	0			
	7	7		6	1	May	1	23		17	11	May	19	5
	10	21		10	15		3	10		25	21			
	14	11												

Maxima of UY Cygni.

Period $13^h\ 27^m\ 27^s.6$. The minimum occurs $1^h\ 53^m$ before the maximum.

	d	h		d	h		d	h		d	h
May	1	10	May	9	6	May	17	3	May	24	23
	2	13		10	9		18	6		26	2
	3	16		11	12		19	9		27	5
	4	19		12	15		20	12		28	8
	5	22		13	18		21	14		29	11
	7	1		14	21		22	17		30	14
	8	3		16	0		23	20		31	17

Maxima of Y Lyræ.

Period $12^h\ 03.9^m$. The minimum occurs $1^h\ 40^m$ before the maximum.

	d	h		d	h		d	h		d	h
May	1	18	May	9	19	May	17	20	Apr.	25	21
	2	18		10	19		18	20		26	21
	3	18		11	19		19	20		27	21
	4	18		12	19		20	21		28	22
	5	19		13	20		21	21		29	22
	6	19		14	20		22	21		30	22
	7	19		15	20		23	21		31	22
	8	19		16	20		24	21			

Variable Stars of Short Period not of the Algol Type.

	Minimum.		Maximum.			Minimum.		Maximum.	
	d	h	d	h		d	h	d	h
S. Triang. Austr.	May 1	2	May 3	4	κ Pavonis	May 15	5	May 19	0
V Velorum	1	23	2	22	W Geminorum	15	5	17	20
W Virginis	2	7	10	12	ζ Geminorum	15	5	20	5
T Velorum	2	8	3	17	T Vulpeculae	15	15	17	0
T Vulpeculae	2	8	3	27	SU Cygni	15	15	16	23
β Lyrae	2	22	6	0	β Lyrae	15	20	18	22
R Crucis	3	13	4	22	S Sagittae	16	3	19	13
Y Sagittarii	3	14	5	9	T Velorum	16	6	17	15
V Carinae	3	16	5	20	V Centauri	16	7	17	18
δ Cephei	3	19	5	4	V Carinae	17	1	19	5
η Aquilae	3	20	6	5	U Sagittarii	17	10	20	9
U Sagittarii	3	22	6	21	RV Scorpii	18	0	19	10
S Normae	3	23	8	9	S Muscae	18	3	21	14
SU Cygni	4	2	5	10	η Aquilae	18	4	20	13
S Crucis	4	22	6	10	S Crucis	19	0	21	12
ζ Geminorum	5	1	10	1	V Velorum	19	10	20	9
V Centauri	5	7	6	18	SU Cygni	19	11	20	19
RV Scorpii	5	21	7	7	W Virginis	19	14	27	19
κ Pavonis	6	3	9	22	δ Cephei	19	22	21	7
V Velorum	6	8	7	7	T Vulpeculae	20	1	21	10
X Cygni	6	11	12	16	S Triang. Austr.	20	1	22	3
T Vulpeculae	6	18	8	3	T Crucis	20	19	22	20
W Sagittarii	6	21	9	21	Y Sagittarii	20	21	22	16
T Velorum	6	23	8	7	T Monocerotis	20	21	28	19
U Vulpeculae	7	3	9	6	T Velorum	20	22	22	7
T Crucis	7	8	9	9	R Crucis	21	0	22	9
S Trianguli Austr.	7	10	9	12	X Sagittarii	21	18	24	15
W Geminorum	7	11	10	2	V Centauri	21	19	23	6
X Sagittarii	7	17	10	14	U Aquilae	22	0	24	4
S Sagittæ	7	18	11	4	W Sagittarii	22	1	25	1
SU Cygni	7	22	9	6	β Lyrae	22	7	25	14
U Aquilae	7	23	10	3	X Cygni	22	20	29	1
S Muscae	8	12	11	23	U Vulpeculae	23	2	25	5
δ Cephei	9	4	10	13	SU Cygni	23	7	24	15
Y Sagittarii	9	8	11	3	S Normae	23	11	27	21
R Crucis	9	9	10	18	S Crucis	23	17	25	5
β Lyræ	9	9	12	16	V Carinae	23	17	25	21
S Crucis	9	15	11	3	V Velorum	23	19	24	18
TX Cygni	10	5	15	8	RV Scorpii	24	1	25	11
V Carinae	10	8	12	12	U Sagittarii	24	4	27	3
U Sagittarii	10	16	13	15	κ Pavonis	24	7	28	2
V Velorum	10	16	11	15	S Sagittae	24	12	27	22
V Centauri	10	19	12	6	T Vulpeculae	24	12	25	21
η Aquilae	11	0	13	9	TX Cygni	24	23	30	2
T Vulpeculae	11	4	12	13	δ Cephei	25	7	26	16
T Velorum	11	15	13	0	η Aquilae	25	8	27	17
SU Cygni	11	19	13	3	ζ Geminorum	25	8	30	8
RV Scorpii	11	22	13	8	T Velorum	25	22	27	7
S Normae	13	17	18	3	S. Triang. Austr.	26	9	28	11
S Triang. Austr.	13	18	15	20	Y Sagittarii	26	15	28	10
Y Ophiuchi	13	22	20	3	R Crucis	26	20	28	5
T Crucis	14	1	16	2	SU Cygni	27	4	28	12
S Crucis	14	7	15	19	V Centauri	27	7	28	18
W Sagittarii	14	11	17	11	T Crucis	27	12	29	13
δ Cephei	14	13	15	22	S Muscae	27	19	31	6
X Sagittarii	14	18	17	15	V Velorum	28	4	29	3
U Aquilae	15	0	17	4	S Crucis	28	10	29	22
V Velorum	15	1	16	0	β Lyræ	28	18	31	20
Y Sagittarii	15	2	16	21	X Sagittarii	28	18	31	15
U Vulpeculae	15	2	17	5	U Aquilae	29	1	31	5
R Crucis	15	5	16	14	W Sagittarii	29	16	32	16

Variable Stars of Short Period not of the Algol Type.—Continued.

	Minimum.		Maximum.			Minimum.		Maximum.	
	d	h	d	h		d	h	d	h
RV Scorpii	May 30	3	May 31	13	U Sagittarii	May 30	22	May 33	21
T Velorum	30	5	31	14	SU Cygni	31	0	32	8
V Carinæ	30	11	32	15	U Vulpeculae	31	1	33	4
δ Cephei	30	16	32	1	Y Ophiuchi	31	1	37	6

Approximate Magnitudes of Variable Stars Feb. 10, 1904.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900.		Decl. 1900.		Magn.	Name.	R. A. 1900.		Decl. 1900.		Magn
	h	m	°	′			h	m	°	′	
T Androm.	0	17.2	+ 26	26	9*i*	R Camel.	14	25.1	+ 84	17	12*d*
T Cassiop.	0	17.8	+ 55	14	8*d*	R Bootis	14	32.8	+ 27	10	9*i*
R Androm.	0	18.8	+ 38	1	7*d*	S Librae	15	15.6	— 20	2	*i*
S Ceti	0	19.0	— 9	53	*s*	S Serpentis	15	17.0	+ 14	40	15*f*
W Cassiop.	0	49.0	+ 58	1	*u*	S Coronae	15	17.3	+ 31	44	7*i*
S "	1	12.3	+ 72	5	13*d*	S Urs. Min.	15	33.4	+ 78	58	8*d*
R Piscium	1	25.5	+ 2	22	13*f*	R Coronae	15	44.4	+ 28	28	6
R Trianguli	1	31.0	+ 33	50	10*d*	V "	15	45.9	+ 39	52	8
U Persei	1	52.9	+ 54	20	11*d*	R Serpentis	15	46.1	+ 15	26	13*f*
R Arietis	2	10.4	+ 24	36	13*d*	R Herculis	16	1.7	+ 18	38	12*d*
o Ceti	2	14.3	— 3	26	3	R Scorpii	16	11.7	— 22	42	*u*
S Persei	2	15.7	+ 58	8	11*d*	S "	16	11.7	— 22	39	*u*
R Ceti	2	20.9	— 0	38	7*i*	U Herculis	16	21.4	+ 19	7	7*i*
U "	2	28.9	— 13	35	*s*	R Ursae Min.	16	31.3	+ 72	28	*u*
R Persei	3	23.7	+ 35	20	13	W Herculis	16	31.7	+ 37	32	10*d*
R Tauri	4	22.8	+ 9	56	11*d*	R Draconis	16	32.4	+ 66	58	8*i*
S "	4	23.7	+ 9	44	11*d*	S Herculis	16	47.4	+ 15	7	12*d*
R Aurigæ	5	9.2	+ 53	28	8*i*	R Ophiuchi	17	2.0	— 15	58	11*d*
U Orionis	5	49.9	+ 20	10	10*i*	T Herculis	18	5.3	+ 31	0	11*i*
R Lyncis	6	53.0	+ 55	28	12*d*	R Scuti	18	42.2	— 5	49	*s*
R Gemin.	7	1.3	+ 22	52	12*d*	R Aquilae	19	1.6	+ 8	5	*u*
S Canis Min.	7	27.3	+ 8	32	8	R Sagittarii	19	10.8	— 19	29	*s*
R Cancri	8	11.0	+ 12	2	10*d*	S "	19	13.6	— 19	12	*s*
V "	8	16.0	+ 17	36	8*i*	R Cygni	19	34.1	+ 49	58	11*d*
S Hydrae	8	48.4	+ 3	27	9*d*	RT "	19	40.8	+ 48	32	*s*
T "	8	50.8	— 8	46	8*d*	X "	19	46.7	+ 32	40	9*d*
R Leo. Min.	9	39.6	+ 34	58	11*d*	S Cygni	20	3.4	+ 57	42	*f*
R Leonis	9	42.2	+ 11	54	10*d*	RS "	20	9.8	+ 38	28	8
R Urs. Maj.	10	37.6	+ 69	18	13*f*	R Delphini	20	10.1	+ 8	47	*s*
R Comae	11	59.1	+ 19	20	*f*	U Cygni	20	16.5	+ 47	35	8*i*
T Virginis	12	9.5	— 5	29	9*i*	V "	20	38.1	+ 47	47	*f*
R Corvi	12	14.4	— 18	42	9*d*	T Aquarii	20	44.7	— 5	31	*s*
Y Virginis	12	28.7	— 3	52	9*i*	R Vulpec.	20	59.9	+ 23	26	*s*
T Urs. Maj.	12	31.8	+ 60	2	12	T Cephei	21	8.2	+ 68	5	6*i*
R Virginis	12	33.4	+ 7	32	7*d*	S "	21	36.5	+ 78	10	8*d*
S Urs. Maj.	12	39.6	+ 61	38	12	S Lacertae	22	24.6	+ 39	48	12
U Virginis	12	46.0	+ 6	6	*f*	R "	22	38.8	+ 41	51	14*f*
V "	13	22.6	— 2	39	12*d*	S Aquarii	22	51.8	— 20	53	*s*
R Hydrae	13	24.2	— 22	46	5*i*	R Pegasi	23	1.6	+ 10	0	*s*
S Virginis	13	27.8	— 6	41	12*d*	S "	23	15.5	+ 8	22	*s*
R Can. Ven.	13	44.6	+ 40	2	10*i*	R Aquarii	23	38.6	— 15	50	*s*
S Bootis	14	19.5	+ 54	16	13*d*	R Cassiop.	23	53.3	+ 50	50	7*d*

NOTE:—*f* denotes that the variable is probably fainter than the magnitude 13; *i*, that its light is increasing; *d*, that its light is decreasing; *s*, that it is near the Sun; *u*, that its magnitude is unknown.

Derived from observations made at the Halsted, McCormick, and Harvard Observatories.

Maxima of RZ Lyræ.

Period $12^h\ 16^m\ 15^s.0$.

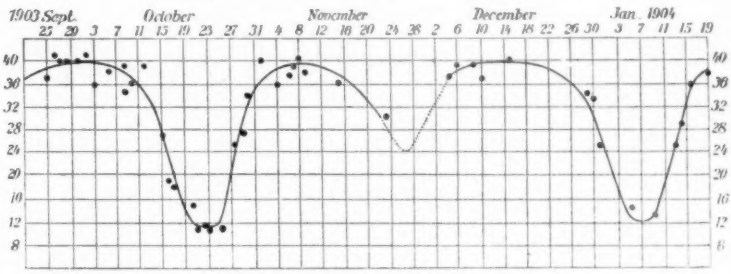
	d	h		d	h		d	h		d	h
May	2	0	May	10	4	May	18	8	May	26	13
	3	0		11	5		19	9		27	13
	4	1		12	5		20	9		28	14
	5	1		13	6		21	10		29	14
	6	2		14	6		22	11		30	15
	7	3		15	7		23	11		31	15
	8	3		16	7		24	12			
	9	4		17	8		25	12			

New Variable Star 4.1904 Vulpeculæ.—This star appears to be of the type of β Lyræ and is announced in *A. N.* 3929 by Mr. A. Stanley Williams. It is BD. + 26°3937, 8.1^m, and its position for 1855 is

R. A. $20^h\ 30^m\ 21^s.86$ Decl. + 26° 06′ 11″.8.

The range of variation appears to be from about 8.0 to 9.7 magnitude in a period of 75 days. A secondary minimum occurs somewhere near 33 days after the principal minimum. Mr. Williams gives the following approximate elements for the principal minimum:

Principal minimum = J. D. 2416486 + $75^d.3$ E.



LIGHT CURVE OF 4.1904 VULPECULÆ.

The accompanying cut shows the light curve as determined by Mr. Williams from 45 visual observations between Sept. 25, 1903 and Jan. 19, 1904.

New Variable 5.1904 Vulpeculæ and 6.1904 Cassiopeiæ.—These are both announced in *A. N.* 3926 by Professor Ceraski of Moscow. Their positions are

		α 1855			δ 1855		α 1900			δ 1900	
		h	m	s	°	′	h	m	s	°	′
5.1904 =	BD + 25 4126	20	23	59.3	+ 25	51.8	20	05	52.3	+ 25	59.4
6.1904 =	BD + 67 244	2	54	51	+ 67	00.6	2	58	49	+ 67	11.6

5.1904 was suspected of variability by Yendell (A. J. 346) and Espen (A. N. 3232). Its magnitude is given in the BD. as 9.3. According to the photographs at Moscow the variation is about one magnitude (between 9.0 and 10.0). The period is not yet determined and is perhaps irregular.

6.1904 is generally constant, but is occasionally found to be about 0.6^m fainter than ordinarily. The observations are insufficient to determine whether it is an Algol type variable or not.

New Variable Star 7.1904 Cygni.—This is announced in *A. N.* 3932 by Professor Ceraski. It is BD. + 42°.4233, 8.3^m and its position is

For 1855	R. A. 21^h 45^m 53^s.9	Decl. + 42°	27′.5
For 1900	21 47 41 .8	+ 42	40 .1

From 20 photographs, during the years 1898-1903, M. Blajko has concluded that the star varies between 8.2 and 9.2 magnitude and that the period is short, not more than five days and perhaps only some hours.

New Variable Star 8.1904 Orionis.—Professor Max Wolf finds on two plates, taken Jan. 10, 1904 with 3¾ hours exposure, a star a little below the 11th magnitude, of which no trace is found upon several plates in the preceding years on which stars of the 15th magnitude were shown. The star is not far from the variable 85.1901 Orionis in the waves of the nebula. Its position for 1900 is

R. A. 0^h 30^m 55^s.8 Decl. — 5° 20′ 25″

U Geminorum.—This star has just passed a short maximum. On March 4 it was at 13.3 magnitude, but on March 8 it was found at 9.9 magnitude. The next night it appeared somewhat brighter. A rapid decrease then set in, and on March 15 the star had sunk to 12.6 magnitude.

Two other maxima have been observed here during the past year. The first was a short one at the end of September; the second was a long one in the middle of December.

ZACCHEUS DANIEL.

PRINCETON, N. J., 1904 March 16.

GENERAL NOTES.

During the last three issues of this publication, our mechanical work has been much hindered, and we have come late each month, especially to reach foreign subscribers. The chief cause of this delay has been due to the fact that the new type-setting machine, promised some time ago, has not yet arrived. We have assurances now that the new machine will be ready for business in a very few days.

In view of the large use of a machine for setting our type in the future, correspondents furnishing matter for publication, will please take great care in preparing copy, so that it may be as nearly accurate as possible to save time and expense in correcting proofs.

Personal Notice.—Harold Jacoby, Ph. D., Adjunct Professor of Astronomy at Columbia University, New York, has been promoted to a professorship. Professor Rees, who has been away since December, 1902, on account of illness, has had his leave extended until July, 1905. Professor Jacoby will continue as Acting Director of the Columbia University Observatory during the interval.

Charles L. Poor, Ph. D., formerly at the Johns Hopkins University, has also been appointed a Professor of Astronomy, and will be associated with Professor Jacoby at Columbia.

Photographic Observations of Comet 1903 *c* (Borrelly.)—Lick Observatory Bulletin No. 52 is wholly given to an account of the photographic observations of comet 1903 *c* (Borrelly), made by Sebastian Albrecht. The Bulletin bears date Jan. 12, 1904. The paper is accompanied by two full page plates containing twelve reproductions of the photographs of the comet between July 15, 1903, and Aug. 15, 1903. The exposures range in time from one hour to six hours. In the latter part of July occur the long exposures when the remarkable changes were going on in the tail of the comet. The photograph taken July 24 between 9^h and $14^h\ 30^m$ is a good one at a critical time. It is to be regretted that the plate for July 26 does not show well the break in the tail at that date.

Apparent Changes in Some of the Canals of Mars.—In Bulletin No. 8 from his observatory, Mr. Lowell gives evidence of apparent changes in a few of the canals he has had under observational study for some time past. He calls particular attention to those canals named Thoth and Amenthes at the opposition of Mars in 1903.

In 1877 Schiaparelli observed and mapped a set of three canals which lay east of Syrtis Major which he named the Thoth, the Triton and the Nepenthes. These markings Schiaparelli must have seen well for he describes them and other markings near by so clearly that they have been identified certainly years later by other observers, although it is noteworthy that he did not discover each and all of them at the same time.

Mr. Lowell in the paper referred to gives a full and detailed account, of the apparent changes, disappearance and reappearance of these markings as reported by Schiaparelli in his memoirs which appeared between 1877 and 1888; he also gives a detailed account of his own study of the same region and makes some suggestions about it worthy of general attention. A part of the concluding paragraph of his paper is as follows:

"Knowing as we now do that that mutable form of matter, the liquid, is largely absent from Mars, that there are no large bodies of water on the surface of the planet and very little of it in any form, we perceive no material means by which such local change in appearance from year to year could be effected. Indeed, even the presence of water would not render the explanation more feasible by the supposition of freshet or other inundation, since if such were able to cause a new marking it could not on that account obliterate the old. There could be no selective action by which the one should be taken and the other left. Nor could meteorological causes very well produce what we see since they would be too impotent, it would seem, to decide that of two possible effects, alike except for a slight shift of locality, and only two, the one should always occur to the exclusion of the other. A year might be wet or dry but it could not well be wet in one place invariably when it was dry in another substantially the same and, what is the crux in the matter, never productive of any mean between the two except as the one gave of its humidity to the other. We are, therefore, led to the conclusion that the two canals do not wax and wane separately from natural causes but are in truth alternatives so connected that the one should increase as the other decreases and vice versa. To explain this state of things, the most probable supposition we can make is that they are so constructed, and that the one lies fallow while the other is at work. It is easily conceivable that a limited water supply should involve a necessity of the sort. It may well be that after one district has enjoyed the water and its results for a certain period,

the supply should then be turned for a time into a neighboring one to be turned back again after a while. The idea follows as a corollary from the theory that the canals perform the office of water supply, and in so far strengthens that theory itself."

The Revised Harvard Photometry.—A catalogue giving the photometric magnitudes of about nine thousand stars, is now approaching completion. All stars in any part of the sky and of the magnitude 6.5 and brighter in any of our photometric catalogues are included. The magnitude of each star will be shown according to each photometric catalogue, whether published here or elsewhere, also its various designations and its class of spectrum. These magnitudes can now be furnished to any astronomer who needs them, and it is expected that in a few months the catalogue will be in the hands of the printer.

The best method of placing the results represented by our photographs in the hands of astronomers is a serious question. Photo-engravings of enlargements of the original negatives are very expensive, and besides reproducing the defects in the original photographs add others of their own. Far more can be shown per square inch on a glass negative than on a paper print. The photographs taken with the Arequipa and Cambridge Anastigmatic lenses cover regions rather more than 30° square on an 8 x 10 plate. Although the aperture but little exceeds one inch, stars as faint as the twelfth magnitude are obtained with exposures of about sixty minutes. Fifty-five of these negatives were selected, covering the entire sky. Contact prints were made from these, and printing from them gave sets of negatives closely resembling the originals, except that the stars were larger and more easily seen. These sets, covering the entire sky, and showing stars down to about the twelfth magnitude, were then offered to astronomers for $15.00, or less than the original cost. The deficit has been charged to the Advancement of Astronomical Science Fund of 1902.

Burnham's Double Star Measures at Yerkes Observatory in 1900 and 1901.—This quarto volume of 75 pages is the work of S. W. Burnham with the 40-inch refractor of Yerkes Observatory during the years 1900 and 1901, and forms part of volume VIII, titled Astronomy and Astrophysics, in the first series of the decennial publications of the University of Chicago.

This paper is concerned with the double star measures that have been made since the completion of Burnham's General Catalogue of 1290 double stars, discovered almost entirely by himself between the years 1871 and 1899, and published in 1900 as Vol. 1 of the Publications of the Yerkes Observatory.

After the publication of the General Catalogue, Mr. Burnham gave his attention to some needed double star work which appears in this paper now before us. All double star observers will be interested in the make-up of his working lists. Mr. Burnham included in those lists stars not likely to be observed elsewhere, long neglected and little known pairs and those which for lack of sufficient measures, or, because of uncertainty of the early results could not be classified in regard to motion or otherwise. For two reasons Mr. Burnham could undertake such pieces of work as these as almost no other astronomer could hope to do as fully and as well as could be expected of him. In the first place he knows the literature of double star astronomy exceptionally well; and in the second place, he has, in the regular use of the great 40-inch refractor of Yerkes Ob-

servatory instrumental power sufficient to test the most delicate and the most difficult cases of visual separation of the components of binaries that are likely to be undertaken anywhere. If his regular share of time at the Yerkes telescope is not sufficient, he has ready access, as in the past, to the 18½-inch Clarke refractor of Dearborn Observatory at Evanston, which instrument Mr. Burnham is proud of, because of its excellent defining power.

On the other hand when we consider the work of the Herschels and South in their several catalogues, the wider doubles which have been long neglected since the time of those early observers presented a needy field of work, because if these wider doubles are true binaries, their circular motion must be extremely slow, and it requires the skill of a first rate astronomer in this science to distinguish between the proper motion of the two and the circular motion of a very slow binary system. Only the very best measurements in such cases are worth very much for records that will be useful at present or in years to come. It must be apparent to Mr. Burnham from this late work in the older fields of double-star observing if he has not known it years ago, that the best work on record from 80 to 100 years ago, including that of the Herschels, now so well thought of, was somewhat deficient in method and care. If one looks over the work of this volume, he will see that Mr. Burnham does not allow his work to go on record with single measures of position-angle, or with estimates of distances of components, as these early observers sometimes did who worked 80 or 100 years ago, and with whose results he now seeks to compare his own. It is quite evident that the comparisons now made, in some cases at least, would be more favorable and more certain than any one can now be sure of. When we see that Mr. Burnham's measures taken two or three times over, on every double star, show variation in hundredths places in micrometer revolution for distances of components, and in tenths of degrees for position angles. The results are in compact form, each set being accompanied by brief notes of interest pertaining to the particular star or stars under measurement.

We notice in the last part of the volume that Mr. Burnham has discovered in the process of this work nearly twenty new double stars, some of them being exceedingly close pairs. One in particular is recorded as having a distance between components of only 0″.21. Observers of double stars will want this publication for study and for reference.

The Mechanics of the Universe is the title of a paper recently prepared by Herman T. C. Kraus, C. E., of Brooklyn, N. Y. It consists of 32 pages, with a brief preface, and gives as its full title: Motion; The fundamental principles of mechanics; or, The mechanics of the universe.

We are sorry to know that any modern civil engineer would commit to the printed page what is apparently hurried, off-hand thinking on such a difficult theme as that which the author of this paper has chosen. He says: "Mathematics have purposely been omitted; for by figures nothing can be ascertained unless they run in a true channel of correct theory."

"The author could not work out details, for this would have required several stout volumes, for the production of which he has neither the time nor the means. The suggestions are made without the consultation of books, nor with the assistance of anybody, so as not to be influenced in the right course."

My stars what a confession! Is this the science of the twentieth century? If Newton, La Place and La Grange had only lived until this time we wonder if they would have said that possibly their mathematics do not "run in a true channel of correct theory!"

A New Incandescent Lamp.—Photographers who can refer to the "Photographisches Wochenblatt" for the 1st of this month may see the illustration of a new incandescent lamp, the invention of Professor Drehschmidt. It burns petroleum, and gives a light equal to 2,200 standard candles. It has no wick, and may, therefore, be classed with the Kitson light. It differs from the latter in the construction of the generator, which is claimed to be more simple in the Drehschmidt lamp. The light is started by ignition of a small quantity of methylated spirit, aud actuating a small air pump, worked by hand. When the lamp is warmed up sufficiently, it appears to require no more attention. A pressure-guage indicates any variation, and a falling off in the light may be remedied by means of the air pump. If the lamp is well constructed and does all that is claimed for it, there should be plenty of scope for its use by photographers. Portraits have been taken by its light in from five to seven seconds, and collodiochloride prints have been made in thirty-five minutes. It is therefore nearly comparable with diffused daylight. For enlarging and the exhibition of lantern slides it should be of great value. The mantles cost eighteen pence, and last for one hundred hours' use. The cost of the petroleum is about one penny per hour.—The British Journal of Photography.

International Exchange Service of the Smithsonian Institution.—We have received a copy of the International Exchange List of the Smithsonian Institution, Washington, D. C., corrected to September, 1903. This branch of the Government service works through the channel, "For the increase and diffusion of knowledge," and is certainly one of the most useful of its kind for the advancement of science known to our present international relations. The last issue of this exchange list makes a thick volume of 492 pages and contains 12,720 addresses in all parts of the world that are entitled to its privileges.

The main purpose of this exchange service is to materially assist institutions and individuals in this country in the transmission of their publications abroad, and also, foreign societies and individuals in distributing their publications in the United States. Any one can readily see how such an arrangement for free registered service would materially assist astronomers who are in all parts of the world in work such as theirs that is essentially related and interrelated in all its various branches. This exchange system is so complete and prompt in its service that the fast mails in every land give it their careful attention, and the result is, astronomers read the work that is done anywhere in the world by their associates very soon after it is completed. It is ranked only by the free telegraphic service that is given to the transmission of astronomical discoveries. Scientific institutions are under great obligations to the Government for such material aid in their work.

The Sun in January, 1904.—The month of January, with the exception of a few of the last days was marked by fine activity in the Sun. There appeared new spots on the Sun on the following days: 3rd, 6th, 13th and 15th; but these spots made their appearance in the regular way, that is to say, showed themselves at the eastern limb and traversed the Sun towards the western edge. Besides these spots, there were some others which were the result of sudden explosions. One of them occurred on the 17th of the month, but it was not very remarkable. Another, extremely curious one, was that of the 22nd. Suddenly

appeared near the center of the Sun fifteen spots, without penumbra, which affected the shape of a J.

On the following day the transformation had been complete. One of the spots was very large, had a fine penumbra and three umbras and near this spot there were twenty-five little spots. Were they not fine? On the following day—Sunday, the 24th—many friends of mine, members of the *Sociedad Astronomica de México* came to my Observatory in order to observe this splendid group, whose general shape was that of a pipe. This fine group disappeared on the 27th. Then commenced a period of calm and it was such a complete one that on the 31st of the month not a single spot was visible on the Sun.

How we may best observe. This is very important for the amateur. The easy way to observe sun-spots consists in projecting them on white card-board, but this ought to be done in a dark room in order to get the minute details of the penumbra and the shape of faculæ. But no method gives such good results as to view the Sun directly through the telescope, using, of course a dark glass or *helioscope.*

The expert Father Secchi recommended sketching on black paper with white paint by means of a little brush; but this is not an easy thing. My clever friend l'Abbe Th. Moreux likes better to draw with sepia color on dark paper.

I think that it is a good and easy way to draw with a soft pencil on dark paper, bluish or grayish, marking the faculæ with white pencil. Only when the drawing is going to be reproduced by the photo-engraving process it is better to draw with china ink on white paper.

In any case, we must not forget to keep a complete collection of our drawings in a note-book, for comparison work. LUIS G. LEON.

CITY OF MEXICO, February 1st, 1904.

Meeting of the British Astronomical Association Jan. 27 1904.—At this meeting there were some interesting questions discussed, one of which was: "The Aspects of the Nebular Hypothesis." The paper on this subject, if correctly reported in the March *Observatory* suggested that it would be better to call that celebrated hypothesis "nebulous" instead of "nebular" and then it went on to some length in support of that contention, making out as one of the speakers said, something of a case against the hypothesis as it is now generally accepted. Several prominent English astronomers participated in the discussion, but, from the report, we do not see that any new or advance ground was made on which astronomers may stand for new work or further advancement in knowledge of theory. Is not Newcomb right in saying we must have more data?

The Stars, a Study of the Universe, which is the title of Professor Simon Newcomb's recent book, received favorable notice in the remarks made by Mr. Crommelin at the January meeting of the British Astronomical Association. He said, "*The Stars, a Study of the Universe,* brought out very forcibly the true grandeur of the Milky Way because he there demonstrated, perhaps, for the first time, how enormously distant it was."

For years past the extent of the universe has occupied the attention of Professor Newcomb largely, and his public utterances on the theme have attracted

the notice of astronomers very generally at home and abroad. It may not be saying too much if we should claim that they have stimulated and are directing in some degree, some of the best astronomical work now going on in America.

Barnard's Micrometrical Observations of the Planet Eros.—The paper before us is another one of those strong pieces of astronomical work that forms part of Vol. VIII of the decennial publications of the University of Chicago. These micrometrical observations of the minor planet Eros were made by Professor E. E. Barnard with the great 40-inch refractor of the Yerkes Observatory during the opposition of 1900-1901. It is probably known to most of our readers that this work with the filar micrometer was part of the general scheme for a systematic series of such observations in this country and in Europe, as an aid for the re-determination of the solar parallax.

In the introductory and explanatory part of these observations, some curious features appear which indicate how the different parts of the great telescope work together in making up the results of observation. Mr. Barnard has applied no correction to the micrometer screw for temperature, because both screw and tube of the telescope are of steel, and, of course, of the same coëfficient, and because they act in opposite directions they mutually cancel each other. A change in the length of the screw by heat or cold is compensated by a corresponding change in length of the tube. This is somewhat surprising in view of the great difference in mass of the two parts. Mr. Barnard has doubtless thoroughly proved this point and knows whereof he speaks. We know he is not likely to admit any uncertainties in his results without giving ample notice of such facts. In carrying observations of Atlas and Pleione of the Pleiades for five years, he found that the change in focal length of the great glass alone is to be taken into account, and only a portion of that—the difference the change in the tube and the change in the focus. For example, from summer to winter the focus shortens from the action of cold on the lens. The shortening of the focus is greater than that of the tube, the extreme difference being about 0.3 inches, though the entire shortening of the focus is upwards of three-fourths of an inch.

The behavior of the polar axis of the telescope during the winter of 1901-2, furnishes another point of interest in regard to the stability of large and heavy mountings in such delicate astronomical tests as those which Mr. Barnard applied to this instrument by the observation of a great many stars for this particular purpose. The result was:

North end of polar axis too low	0′ 39″
North end of polar axis too far west	0′ 45″

In the winter of 1897 the position was:

North end of polar axis too low	0′ 10″
North end of polar axis too far west	1′ 00″

apparently a good showing in regard to harmful change of place.

This quarto paper has only 40 pages in it, but it means work, and a large amount of it. The explanatory part is brief and to the point, and then comes solid pages of figures by the score, giving full data of the observations and the results of reduction up to and including the parallax factors in right ascension and declination. Tables follow showing the comparison stars used, barometer and thermometer records, and other information deemed useful in this work.

This paper appears to present a very full and thorough study of the posi-

tions of the planet Eros between October 2, 1900 and February 5, 1901. We notice that there is an error at the top of page 25 and on several others following, in regard to the year. This will not mislead any one probably because, in the body of the table, page 24, the correct year is given. There are also other tables of observations of Eros, for other years, making this line of work quite as complete as could be expected from any single observer.

The one thing that we regret about the micrometrical measures of Eros is what Mr. Barnard has already mentioned to us, in a personal interview a few months ago. That was, that some one person competent to make the micrometrical measures and also to photograph the same regions should carry the two lines of work right along side by side under the same conditions, with the same instruments, at the same time. If this could have been done, it seems strongly probable that much of the error that is now to be feared, for a lack of these circumstances, might possibly have been eliminated from the results that must be combined from sources that must greatly vary in all these particulars.

Two Stars with Variable Radial Velocity.—We have been much interested in reading the accounts given by Frost and Adams in the study of the radial velocities of stars where there seems to be variation. In the course of recent work with the Bruce spectrograph Yerkes Observatory on stars having spectra of the *Orion* type the two stars *u* Herculis and 57 Cygni have been found to show large variation in their radial velocities. Four consecutive results on the first star are $-65, -44, +101, +98$ kilometers of velocity. These measures may be in error, as the observers think, by several kilometers, because the lines of its spectrum are broad and diffuse. But the star is one of special interest on account of its being a photometric variable of irregular period.

The other star, 57 Cygni, also shows large variation in radial velocity in the two results given, viz: $-114, -23$. An interesting fact also appears on one of the plates, when the magnesium line at λ 4481.4 appears to have a second component, which is displaced toward the red by an amount corresponding to a velocity of about + 56 km. No second component can be seen on the other of the two plates from which the above results come. These observers say: "In this connection it may be stated that on different plates we often find marked differences in the distinctness of the lines in spectra of stars varying rapidly in velocity, doubtless in part due to the change in velocity during the exposure."

In recent articles these observers have called attention to other stars having large variation of velocity in the line of sight. This must certainly prove to be a new and most fascinating field of research for observers in it who have the instrumental equipment equal to its needs.

Astronomical and Astrophysical Society will hold its next meeting at Philadelphia during Convocation week 1904-05, in affiliation with the American Association for the Advancement of Science.

H. Struve, Director of the Observatory at Königsburg has been appointed Director of the Observatory at Berlin.

Mathematics and its History was the theme of the address of the vice president of Section A, American Association for the Advancement of Science at the St. Louis meeting. It was delivered by George Bruce Halsted, and a prominent feature in it was the modern geometry.

Remarkable Effect of an Aurora Borealis upon an Electro-magnetic Clock.—In A. N. 3932 Dr. Ernst Hartwig writes of the influence of an aurora borealis, on the night of Oct. 31, 1903, upon an electro-magnetic clock in his study at Bamberg. The pendulum of the clock receives an electro-magnetic impulse from two accumulator cells every minute and, when the cells are in order, has a constant rate through the year. On this night, however, the pendulum was accelerated in an extraordinary manner, as if the accumulators were over charged. On the morning of Nov. 1 Dr. Hartwig found the clock violently disturbed, the pendulum striking on both sides of the case, and the hand pointing several hours and perhaps over a whole revolution ahead, while because of the too violent swing several seconds-intervals were skipped at a time. The accumulators had not been charged for several days past, so that it must have been an earth-current resulting from the aurora which produced the disturbance.

M. O. Callandreau.—It is but a short time since one read in the *Bulletin Astronomique* the words of generous appreciation and sympathy with which M. Callandreau committed to the grave the remains of his friend and colleague, M. Prosper Henry. There was no suspicion then that in a very short time his own funeral oration would have to be spoken, or that the staff of the Paris Observatory was so soon to suffer another almost irreparable loss by the removal of another zealous officer equally renowned, equally devoted to the interests of the observatory, but adding to its reputation in a very different direction.

For many years attached to the service of the observatory, M. Callandreau took part in the routine observations, more especially confining himself to the extra-meridional work. Small planets, comets, double stars, each in turn came under his notice, but though a skillful and painstaking observer, he will not be remembered for his diligence in this direction.

Trained in a school directed by profound mathematicians, in which, perhaps, the influence of Gylden can be recognized, and gifted with an unusual analytieal skill, he attacked nearly all the questions of celestial mechanics, and everywhere left traces of his powerful and inventive mind. His acquaintance with all the resources of analysis as applied to the practical needs of asrronomy enabled him not only to improve the methods employed in some of the more recondite applications of mathematics to astronomical problems, but induced him to open up new paths of inquiry, which are likely to exercise no inconsiderable influence on many questions of abiding interest and prime importance. It will be sufficient here to refer to his method of treatment of definite integrals which occur in the calculations of planetary perturbation, to the consideration he gave to the troublesome question of perturbations of small planets in which the mean motion is nearly commensurable with that of Jupiter, to his occasional references to the theory of the Moon, to the figures of the planets, to problems in geodesy, to show how wide an outlook he possessed over the necessities and the difficulties of mathematical astronomy. It is perhaps in some measure to be regretted that

his attention wandered over a variety of inquiries, for if everywhere he illuminated the subject under discussion, greater concentration in a particular subject might have added to his reputation and left a deeper mark on the history of his time. Perhaps his "Contributions to the Theory of Cometary Capture" comes nearest to a complete treatise, and his services in this department of astronomy will be long remembered. Some of his papers bear marks of being suggested by his professional work in connection with the École Polytechnique, where he occupied the chair of astronomy. His life was a busy one, divided between his duties at the observatory and his professorial engagements, while his kindness of disposition induced him to give willing assistance to those who applied to him. The writer of these few lines gratefully acknowledges more than one kindness he has received at the hands of this distinguished mathematician and astronomer.

Member of the Paris Academy of Sciences and honored in his own country and among his colleagues, we look in vain for his name among the foreign associates of the Royal Astronomical Society. The kind of work on which he concentrated his attention does not appeal to a numerous class of astronomers, especially would it fail to collect the suffrages of amateurs. But those who read his numerous papers will admit the ability by which they are distinguished and the informing character of their contents. We extend a respectful sympathy to the institution that is bereft of his services, to his colleagues who lose an illustrious example, and to his pupils who are deprived of an able and encouraging teacher.—*Nature*, March 10, 1904. W. E. P.

The Croatian Philosophical Society in Zagreb (Agram), which is devoted to Natural Science among the Croatian people, and was founded in 1887, has organized an astronomical section with the purpose of cultivating that science and popularizing it among the Croatian people. In furthering this project an astronomical observatory has been built at the capital of the kingdom of Croatia, Zagreb, which was ready for use Nov. 1, 1903, and is under the directorship of the undersigned.

The observatory occupies an ancient tower of 16m. in height, with an area about it of 121 sq. m. The instruments consist of an equatorially mounted refractor of 6.4 inches aperture and a smaller one 4¼ inches; both are by Reinfelder & Hertel, the larger equatorial having clock-work. Besides these telescopes there are two other instruments of 4.2 inches clear aperture viz, a refractor by Steinheil and a reflector by Fritsch, both with equatorial mounting.

The work of the new observatory is to be on the Sun, the Moon, the planets, variable stars and colored stars. Observations will be published in the Journal of the Society: "Glasnik hrvatskoga naravoslornoga drustva" which will appear twice a year, in the months of July and December. It will receive and contain articles and notes in Croatian, Latin, English, French, German, Russian and Italian.

The Director of the Astronomical section solicits the exchange of certain publications and the following address for his own: "Astronomijski observotorij naravoslovnoga drustva" Zagreb, Popv toranj, Croatia.

PROF. DR. OTTO KUCERA.

Publications Received.—The following is a list of some of the publications received recently:

Greenwich Magnetic and Meteorological Observations, 1900.

Greenwich Spectroscopic and Photographic Results, 1900.

Greenwich Astronomical Results, 1900.

Annals of the Royal Observatory, Cape of Good Hope, Vol 11, pt. 3. Occultations of Stars by the Moon, 1881 to 1895.

Observations of the Sun, 1894 and 1895, Odessa.

A full set of Meteorological Observations from Lyons, France, for 10 years.

Volumes V, VI, VII of the Photographic Catalogue of the Heavens, containing rectangular coördinates in zones respectively, $-1°$, $+1°$; $-2°$, $0°$; $-3°$, $-1°$ and 0^h, $6^h\ 56^m$; 0^h, $4^h\ 28^m$; 0^h, $6^h\ 8^m$. Observatoire d'Alger.

Observations during the year 1902, Meteorologic, Magnetic and Seismatic, at Pola.

Magnetic Observations, Central Magnetic Observatory, Mexico.

Determination of Azimuth and Latitude by M. Rajna.

Vol. 51. The Photographic Atlas of the Moon, Wm. H. Pickering.

Meridian Circle Observations of Eros and Comparison Stars, Harvard College Observatory.

Meridian Circle Observations of Nova Persei No. 2 and Comparison Stars, Harvard College Observatory.

Distribution of Stars, Harvard College Observatory.

Intensity of Atmospheric Lines in the Solar Spectrum, Harvard College Observatory.

Observations with the Meridian Photometer, 1899-1902, Harvard College Observatory.

Geographical Position of the Arequipa Station in Peru, South America, by Winslow Upton, Harvard College Observatory.

Observations at Blue Hill Meteorological Observatory, Harvard College Observatory.

Publications of the U. S. Naval Observatory, Second Series, Vol. V. Meteorological Observations and Results, 1893-1902.

Publications of the U. S. Naval Observatory, Second Series, Vol. III. Eros and Reference Stars, Zodiacal Stars, Prime Vertical Observations, 1883-1884.

Report of the Astronomer Royal to the Board of Visitors of the Royal Observatory, Greenwich.

Southern Circumpolar Researches, Part I. Heliometer Triangulation of the Southern Circumpolar Area.

The Law of Contraction of Gaseous Nebulæ.—In the Transactions of the St. Louis Academy of Sciences, Vol. XIII, No. 5, Professor Francis E. Nipher discussed the law of contraction of gaseous nebulæ, by the aid of mathematical analysis. We only have space, now, to give the concluding paragraphs of this interesting paper. They are as follows:

"The conditions here discussed, may perhaps be brought about in some such way as this. An infinitely diffused mass of gas occupies an infinite space. It is surrounded by an infinite series of infinite spaces, having perhaps an increasingly higher order of magnitude. A great meteorite, or a world, strays into the nebula, and probably sets it into rotation. The nebulous mass gravitates towards the solid nucleus, which has been already slightly warmed by frictional contact with the diffused gas. As the gravitating action continues, the temperature rises, and the solid mass, while still remaining solid, becomes also a liquid and a gas. The bounding surface between solid and gas has disappeared. How else

can gaseous pressure develop in an infinitely diffused mass of gas having a temperature at which all gases are solid?

"This pressure thus developed, is automatically applied in a perfectly definite way, as radiation and contraction proceed. If, as the temperature rises, the heat radiates more and yet more rapidly, the operation is thereby hastened, but the law of contraction remains unchanged. The relations between P, δ, and T must remain invariable.

"These equations are now in condition to be linked with the solar radiation constant, and the time element. They may thus serve to permit a re-examination of the history of the evolution of the solar system."

BOOK NOTICES.

Taylor's New Plane Trigonometry—Professor James M. Taylor, of Colgate University, has prepared a new book on Plane Trigonometry. It is published by Ginn and Company, Boston, Mass. The text is reasonably full of well-chosen matter, compact in form, with answers to problems in last pages, and all within a compass of 171 pages. The copy before us is not supplied with the ordinary trigonometrical tables.

The author's aim, well carried out, has been to prepare a text-book that shall be clear, concise and practical, yet thoroughly scientific, with proofs that are simple, direct yet fully rigorous. He uses directed lines and trigonometric ratios and gives to these fundamental ideas in trigonometry the prominence really due to each of them individually and relatively. It is important that a student from the beginning get a clear idea that directed geometric lines are measured by ratios in terms of trigonometric symbols.

The distinction between identities and equations is emphasized in definition, treatment and notation and attention is called to the reciprocal pairs of ratios in a way to fix in mind these useful relations in ordinary work. The formulæ are in heavy-faced type, and the proofs leading to them are made geometrically general according to the best usage.

The exercises are abundant and seem to be well-chosen, although this we can not be sure of without a sufficient test of them in the class-room. The geometrical figures are neatly drawn, clearly lettered and generally are satisfactory to the teacher's experienced eye. This fact has value in training the mind for finished work, in the student's preparation, his class-room work and his habits of thinking and doing.

We are sorry to see in so good a book generally, some blemishes. Why will some good mathematicians persist in writing fractions with numerator and denominator on the same line, with an inclined line between them, instead of writing the numerator above, and the denominator with a horizontal line between them? That way of writing a fraction in arithmetic, algebra or trigonometry is both inelegant and inaccurate. In our judgment it is a pure commercialism that teachers ought not to tolerate. Its inelegance is too often seen in the written exercises of students and its inaccuracy is obtrusive in oral explanations in the class-room.

The seventh and eighth chapters which treat of periods, graphs, important limits, computation of tables, hyperbolic functions, complex numbers and De Moivre's theorem are instructive and very attractive parts of this new book, for the student who wishes to go a little further than the elementary line of work previously given.

Plane and Solid Geometry by Sanders.—The author of this new text-book is Alan Sanders, of the Hughes High School, Cincinnati, O. The publishers are the American Book Co., New York, Cincinnati and Chicago.

The leading features of this text are the omission of parts of demonstrations, the introduction, after each proposition, of exercises bearing directly upon the principle of the proposition, all constructions such as drawing parallels, erecting perpendiculars, etc., are given before they are required to be used in demonstrations; exercises in Modern Geometry; and propositions and their converses.

In the construction of figures the added lines for the sake of proofs are made lighter than the outlines of the principal figures and variety of construction is prominent. The matter of the text is abundant and varied. In the hands of a competent teacher it will be suggestive and resourceful. Classes not fortunate in having an experienced teacher might go wild in the use of it, because so much depends on the teacher.

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Contributors are asked to prepare copy carefully, and write *all proper names very plainly*. If other language than the English is used to any considerable extent it should be type-written. Manuscript to be returned should be accompanied by postage for that purpose.

All Drawings for publication should be done in India ink, twice the size that the cut will be on the printed page. The lines, figures and letters should be made even, very smooth and uniformly black in every part of the copy, in order to secure the best reproductions possible by the modern quick processes of engraving now most generally used.

Proofs will generally be sent to authors living in the United States, if copy is furnished before the tenth of the month preceding that of publication. We greatly prefer that authors should read their own proofs, and we will faithfully see that all corrections are made in the final proofs.

Renewals.—Notices of expiration of subscription will hereafter be sent with the last number of this publication for which payment has been made. It is especially requested that subscribers will send renewal, or order for renewal promptly as this publication will not be continued beyond the time for which it has been ordered.

Astronomical News.—It is very much desired on the part of the management, that brief news paragraphs of astronomical work in all the leading observatories of the United States be furnished to this publication, as regularly and as often as possible.

The work of amateur astronomers, and the mention of "personals" concerning prominent astronomers will be welcome at any time

The building and equipping of new observatories, the manufacture, sale or purchase of new astronomical instruments, with special reference to improvements and new designs, and the results of new methods of work in popular language, will be deemed very important matter and will receive prompt attention. Appropriate blanks have been prepared and will be sent out generally to secure this important information. It is greatly desired that all persons interested bear us in mind and promptly respond to these requests.

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